

# The Philippine Agriculturist

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## SIGNIFICANT VALUE OF SCIENCE<sup>1</sup>

With industry already so deeply obligated to science and so obviously dependent upon it for future progress it is a curious anomaly that so large a proportion of manufacturers still are committed to worn-out methods and still are entangled in problems for which solutions have long ago been found. For many of these manufacturers the situation is a dangerous one, for science has a disconcerting way of distributing her gifts to those who recognize their value. The mathematical researches of Abbe transferred the making of optical lenses from England to Germany. The monopoly in sulphur, which Sicily had so long enjoyed, was broken almost over-night by the Frasch process. Of forty-four American companies engaged a few years ago in the recovery of potash only one remains in business today, and it is that one alone which organized a research staff.

The practical man too often confounds science with mere theory, so sees little place for it in his business. But science, in its industrial applications, is as intensely practical as a market report or a balance sheet. It represents the accumulated experience and organized knowledge concerning the behavior of things, which thousands of the world's best minds have acquired by the incessant questioning of nature for more than a hundred years. As such the manufacturer ignores it at his peril. An enlightened self-interest should lead him to welcome its teachings and generously support research, for research is the mother of industry.

## RESULT OF RESEARCH IN RAW MATERIALS

Industry looks to agriculture for much of its raw material, and the farm is correspondingly dependent on the factory for fertilizers, insecticides, agricultural machinery, and home supplies. Fortunately for both farmer and manufacturer, science has long been intensively applied to the study of agricultural problems in the laboratories and greenhouses and on the testing plots of universities, government departments, and agricultural experiment stations. Botanists have searched the earth for hardier or more prolific species; chemists have analyzed soils without number to determine the relation of composition to plant growth; entomologists have studied the life cycle of insect pests; meteorologists have for years read thermometers, barometers and anemometers, and sent their instruments above the clouds; biologists have studied microscopic fungi, cultivated bacteria, and developed serum—all to the end that agriculture should

<sup>1</sup>Extracts from "The Contribution of Science to Manufacturing" by Dr. A. D. Little of Arthur D. Little, Inc., Boston. Published in *The Annals of the American Academy of Political and Social Science*. May, 1925.

be established upon a surer and more efficient basis. An Austrian monk applies the scientific method to the growing of peas and discovers the laws that control heredity in plants and animals. Because of all this the cotton spinner has better grades of cotton; the beets coming to the refinery carry 18 per cent of sugar instead of 6 per cent; tobacco plants grow 30 per cent more leaves fit for wrappers; wheat has more gluten; corn and potatoes more starch; hogs are heavier, cattle bigger, and hides larger and better.

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Wealth must be produced before it can be distributed.

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"Agriculture is a study that offers attractive opportunities regardless of whether the student wishes to enter the teaching profession, to engage in scientific research, to accept a position of leadership among country people, to engage in one of the many commercial activities calling for trained agriculturists, or whether he or she desires a fuller and richer life 'back on the farm'."

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"One of the middle western colleges of agriculture (U. S. A.), in a survey of occupations followed by graduates of the college, found that its graduates in agriculture have open to them 140 different kinds of employment.

# STUDIES ON THE TOXICITY OF COPRA MEAL: I.<sup>1</sup>

VICTOR SULIT

WITH THREE CHARTS

## INTRODUCTION

Of the feeding stuffs produced in the Philippines, copra meal is the one that is gaining most in favor among keepers of animals; as a feeding concentrate it is being used in increasingly large proportions. In all countries importing copra, copra meal is used as feed in large amounts. Locally, its use as a feed was formerly confined to hogs, but now it is fed to practically all farm animals, including chickens. A few years ago a food specialist in the Islands advocated its use as a human food. Although at times copra meal is used as a fertilizer and also as a fuel, its chief use would seem to be as a feeding concentrate for farm animals.

In this connection, it is of importance to note that in feeding large amounts of copra meal to guinea pigs, Derecho (1921) observed that in spite of a liberal supply of antiscorbutic vitamin, the animals suffered physiological disturbances which could not be reasonably considered as due to vitamin deficiency. He found that copra meal alone, or even when supplemented with purified food-stuffs, is highly constipating for guinea pigs. His experiments presented three striking phenomena regarding copra meal as a feed: First, the decline in weight and in health of animals which were fed with rations in which copra meal was the basal ingredient; second, that varied symptoms of sickness were produced, regardless of the absence or presence of any of the factors which produce deficiency diseases; third, the failure of the animals to recover on the administration of orange juice. It would thus seem that in addition to the absence of certain food factors in copra meal, it possesses some toxic properties which exert deleterious effects on animals. It was the object of the present investigations to study this phase of the subject.

### *Review of the past work*

No literature bearing directly on the toxicity of copra meal was available to the writer. Quite extensive and exhaustive work has been done in the study of the toxic properties of cotton seed meal, but, inasmuch as the two products are very different, the results obtained were of little value in the present investigation, even for comparative purposes.

Results of the different analyses of copra meal by Lindsey (1914), Cathcart (1916), Smith (1918), and Caray (1921) show that it contains all the food elements in proper proportions. Determination of its biological efficiency by Lindsey (1914) showed that its constituents have a very high coefficient of digestibility. Feeding experiments by Fingerling (1909), Skelton (1911), Cranfield (1912), and Carlier (1913), proved that it is a very efficient protein concentrate.

<sup>1</sup> Part I of thesis presented, 1923, for the degree of Master of Science from the University of the Philippines, No. 216; Experiment Station contribution No. 335.

This was further confirmed by Ewing and Spence (1918). Johns, Finks, and Paul (1919) working on the nutritive value of commercial coconut press cake found that it furnishes the necessary protein for normal growth. Lindsey (1914) and Maynard and Fronda (1921) found that copra meal is an effective supplementary feed. Jones and Johns (1920) found that its proteins on hydrolysis yield nearly all of the amino acids. Investigation by Johns, Finks, and Gerrdorff (1919), Johns and Jones (1920), and Santos (1920) shows that all the amino acids found to be necessary for growth, development, and preservation of life are present in coconut protein in sufficient amounts. It contains a sufficient amount of vitamin A (Sherman and Smith, 1922), and a little of vitamins B and C (Jansen, 1918, and Haliburton and Drummond, 1918). These studies show that copra meal promises to be a very efficient protein concentrate and a highly desirable feed.

#### MATERIALS AND METHODS

*Animals.* Guinea pigs were used as the experimental animals. Unless otherwise noted the guinea pigs were kept in pairs throughout the tests.

*Copra meal.* Two kinds of copra meal were tried. The first kind, copra meal I, was an expeller product obtained from the oil mills of San Pablo, Laguna. Copra meal II was a hydraulic product, obtained from Manila. The latter is the kind that will probably be in general use in the future. The analyses of these two follow:

TABLE 1

*Showing the composition of copra meal I and copra meal II <sup>a</sup>*

| SAMPLE             | MOISTURE | FATS AND OILS | ASH  | PROTEINS | CRUDE FIBER | CARBOHYDRATES |
|--------------------|----------|---------------|------|----------|-------------|---------------|
| Copra Meal I.....  | 15.21    | 15.91         | 5.57 | 16.53    | 12.52       | 34.26         |
| Copra Meal II..... | 12.83    | 5.77          | 7.26 | 17.5     | 15.73       | 40.91         |

<sup>a</sup> The analyses were made at the U. P. College of Agriculture Experiment Station Food Laboratory.

The expeller product is sold in granulated form, more or less in lumps, while the hydraulic product comes out in the form of hard compressed blocks or cakes. Both crumble to powder and turn rancid quickly on standing, possibly attended by absorption of moisture and chemical changes. As they come from the factory both products have a slightly sweetish smell.

#### *Preparation of feeds*

*Butterfat.* Butterfat was obtained by warming butter of high quality in a beaker over a water-bath at temperatures of from 40° C.-50° C. The top layer of fat was separated and used as butterfat.

*Copra meal, casein, corn, and rice.* These were separately pulverized and passed through a one-millimeter sieve.

*Dextrin.* In the first series of these experiments, dextrin was used for starch. Dextrin as purchased from the market was used.

*Starch.* Corn starch with the trade name, "Liberty," was purchased from the local market and used without further treatment.

*Salt mixture.* Salt mixture No. 1, the synthetic salt mixture number 207 of Osborne and Mendel as given in Hawks' *Practical Physiological Chemistry* (1921), was used throughout.

*Tomato juice.* Fresh ripe tomatoes, generally of different varieties, were purchased from the local market from day to day as needed. The tomatoes were thoroughly washed in cold boiled water and passed through a meat grinder. The mass was filtered through a piece of cloth. The filtered juice was used without further treatment.

*Grass.* Fresh Guinea grass (*Panicum maximum* Jasq.) was chopped into pieces about five centimeters long.

*Water.* For the first series of experiments rain, and later, boiled water was used.

#### *Preparation of the rations*

*Control ration.* A control ration with the following composition was used:

|                      |      |       |
|----------------------|------|-------|
| Corn.....            | 37.0 | grams |
| Rice (polished)..... | 30.0 | "     |
| Casein.....          | 15.0 | "     |
| Salt mixture 1.....  | 4.0  | "     |
| Butterfat.....       | 14.0 | "     |

During the first series of the experiments the animals on control rations became highly constipated due, possibly, to low roughage content. Later, this trouble was largely eliminated by the addition of some grated quantitative filter paper. The addition of fiber, correspondingly decreased the protein intake of the control animals.

*Experimental rations.* To determine the possible deleterious effect of copra meal, rations with varying proportions of it were made. All the rations were calculated to contain about the same percentage of protein and other necessary ingredients.

The following are the rations used:

#### Ration 1

|                     |    |       |
|---------------------|----|-------|
| Copra meal.....     | 75 | grams |
| Casein.....         | 7  | "     |
| Salt mixture 1..... | 4  | "     |
| Butterfat.....      | 14 | "     |

#### Ration 2

|                     |    |       |
|---------------------|----|-------|
| Copra meal.....     | 80 | grams |
| Casein.....         | 6  | "     |
| Salt mixture 1..... | 4  | "     |
| Butterfat.....      | 10 | "     |

#### Ration 3

|                     |    |       |
|---------------------|----|-------|
| Copra meal.....     | 85 | grams |
| Casein.....         | 5  | "     |
| Salt mixture 1..... | 4  | "     |
| Butterfat.....      | 6  | "     |

#### Ration 4

|                     |      |       |
|---------------------|------|-------|
| Copra meal.....     | 37.5 | grams |
| Casein.....         | 13.5 | "     |
| Starch.....         | 31.0 | "     |
| Butterfat.....      | 14.0 | "     |
| Salt mixture 1..... | 4.0  | "     |

As young animals were used, differences in physiological reactions may easily be due to the amounts of protein. This was obviated by increasing the amount of the protein in each of the rations by a liberal use of casein to about twenty per cent. The control ration contained fifteen per cent of protein.

Vitamin A was supplied by butterfat. Because of the presence of vitamin A in copra meal, rations containing large proportions of copra meal received correspondingly less proportion of butterfat. By so doing, the unnecessary high amounts of fats in the rations containing large amounts of copra meal, which might be a source of trouble, was avoided.

Because of the great susceptibility of guinea pigs to scurvy, fresh tomato juice varying from 5 cc. to as high as 20 cc. was added to their feed daily (Hess, 1920.)

#### *Care of animals*

The animals were kept in empty gasoline boxes. The bottoms of these boxes were either perforated or replaced with slats to facilitate the drainage of urine and liquid matter. They were cleaned at least once a week.

*Feed containers.* All the rations were kept in glass jars, which were cleaned once a week. During the first series of these experiments, porcelain cups and glassware were used in feeding. Later, these were replaced by regular feeding cups made of galvanized iron. All the feeding and drinking cups were thoroughly cleaned once a day and scalded twice a week.

*Feedings.* Fresh feed was given to the animals as needed.

*Tomato juice.* The juice, in some cases, was mixed with the feed, in others it was administered separately.

*Weighing the animals.* In all cases the animals were weighed once a week in a "Cenco" balance.

#### EXPERIMENTS AND RESULTS

To check the methods of the feeding and care of the animals, control sets were maintained with each series of experiments. These control feedings were prolonged through several months, even after the death of the other experimental animals.

#### *Control feedings*

Diet No. 5, which was used in control feedings, was found by Macy and Mendel (1920) satisfactory for the growth and maintenance of guinea pigs. Two animals, No. 11 ♀ and No. 12 ♂ fed with this ration and supplemented with fresh tomato juice, continued increasing in weight even up to the seventh month. These animals were used as control for the others on copra meal I experiments.

To check the experiments on copra meal II, two animals, No. 43 ♂ and No. 44 ♀, were given ration 5. Both animals decreased in weight for the first two weeks, due possibly to the change of feed, but in the third week they began to grow. They showed vigor and normal health to the end.

Two animals, No. 23 ♀ and No. 24 ♂, were given ration 5 plus tomato juice. Decreases in their respective weights were observed during the first week, after which the animals gained in weight, very slowly at first, but later on quite normally. Their growth for a period of seven months was quite normal. The animals maintained good health throughout the period of the experiment. (See chart 1.)

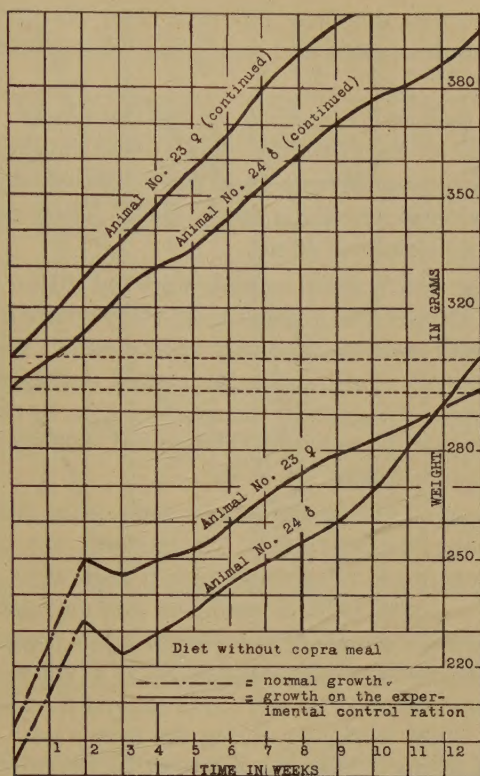


Chart 1.—Typical weight curves of male and female guinea pigs for a period of several months, showing their behavior on a diet containing no copra meal.

### *High proportions of copra meal I*

Derecho (1921) found that copra meal alone or even when supplemented with purified food was highly constipating and caused congestion and hemorrhages in the cecum and rectum of the animals. Administration of orange juice did not cure the animals. In a preliminary experiment connected with this investigation, three animals fed exclusively with copra meal were constipated, became weak, voided bloody feces and died in about three weeks.

*Copra meal, 85 per cent.* Two animals, No. 7 ♀ and No. 8 ♂, were given ration 3. The animals at first did not seem to relish the ration, but, after a week's feeding, their intake increased until the end of the third week, then it began to fall off very slowly until a day or so before death.

After the first week, the animals showed marked inactivity although they looked quite normal. This inactivity was accompanied by gradual softening of the feces. In the third week, the fur became rough, the feces began to be abnormally soft and sticky, and general body emaciation began to set in. In the fourth week, profuse throwing of feces began and general weakness and emaciation became very marked. During all this time the animals decreased in weight, at first, slightly, and then abruptly. At the end of the fourth week, the animals were very weak, walking slowly, with erect rugged hair and highly arched backs. However, they still took in food although with greater effort. They showed extreme sensitiveness to light. Guinea pig No. 8 ♂ began throwing

blood with the urine, had diarrhea and died after thirty-four days. Animal No. 7 ♀ vomited a colorless liquid and was found lying prostrate on its belly just before death.

The food intake increased materially to the third week. As the manifestation of sickness began to be distinctly shown, food intake decreased slightly. Tomato juice was then increased from 10 to 20 cc., but effected no cure. Abrupt decrease in weight followed and the animals died. These results seem to show that copra meal has a deleterious effect.

*Copra meal, 80 per cent.* Four animals were fed ration 2. This ration did not keep any of them alive. The animals from the beginning of the test declined in weight, first gradually and then abruptly until death. The food intake of the animals increased gradually until about the end of the third week. When the severity of sickness was very marked, the intake began to decrease very slowly. The animals were observed to continue taking food, but with the utmost effort, up to several hours before death.

The manifestations of sickness produced were quite different and occurred at different times among the individuals. Animal No. 1 ♂ showed normal condition for a period of one week, after which time it grew weak and the feces began to be soft and sticky. Later, general weakness and emaciation set in, hair became rugged, feces became streaked with blood, urine began to thicken and at the end of 30 days the animal died. Animal No. 2 ♀ showed exactly the same symptoms, but at quite different times. This animal died after 33 days. Animal No. 5 ♀ showed slight weakness during the first week, and later softening of the feces began to set in. This was followed by severe diarrhea and finally both liquid and clotted blood was voided. The animal, however, ate normally and drank water freely. After 31 days it died; during the last day it walked very slowly. Animal No. 6 ♂ became emaciated after one week under experiment. In the second week, diarrhea developed. The animal became very quiet and weak; later on, liquid blood was thrown with both the feces and the urine. During the fifth week, the animal was much emaciated, the back was highly arched and the hair was rough and erect. The animal died after 34 days under experiment.

*Copra meal, 75 per cent.* Two animals, No. 3 ♀ and No. 4 ♂, were given ration 1. These animals, for a period of about four weeks, maintained normal body appearance and took food very readily. Number 3 ♀ gained in weight during the second and third weeks. Their weights decreased less abruptly than the animals in the lots just discussed.

Animal No. 3 ♀ in the fourth week was still healthy, although showing slight softening of the feces. In the fifth week, a condition of general weakness and emaciation developed, the feces became soft and sticky and later, diarrhea appeared. Slight blood clots were found with the feces and the animal died after 39 days. Animal No. 4 ♂ showed softening of feces at the beginning of the second week, although a healthy condition was maintained for two weeks. In the third and fourth weeks the animal showed slight emaciation and the hair became rugged and coarse. In the fifth week, general weakness developed, the animal remaining quiet, walking very slowly at times, and occasionally showing great sensitiveness to light. Very slight diarrhea developed and the animal died after 42 days under experiment. No blood exudation was noticed with this animal. (See chart 2.)

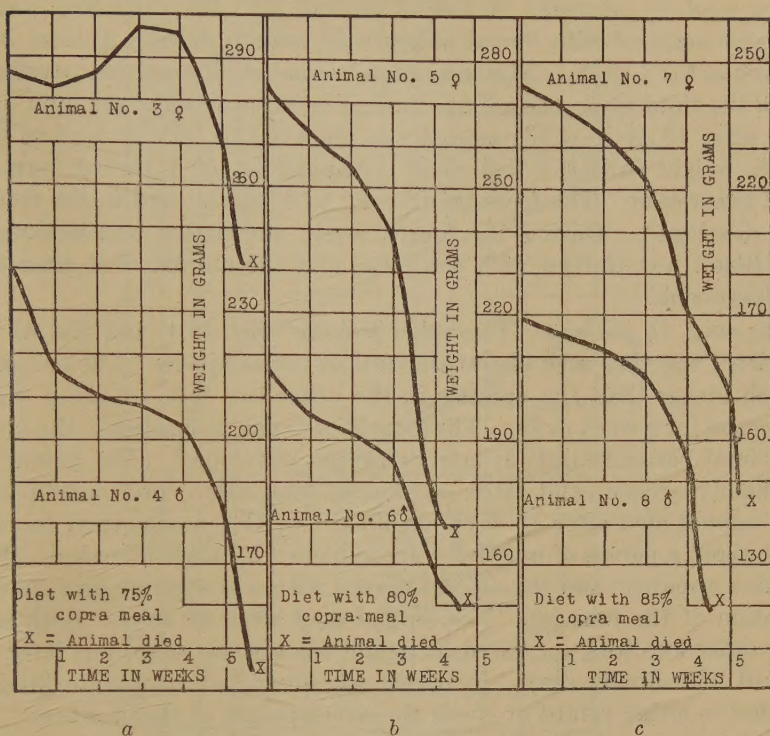


Chart 2.—Typical weight curves of male and female guinea pigs showing their behavior on a diet which contained all the necessary food elements in sufficient amounts, but which consisted of high proportions of copra meal. (a) Diet with 75 per cent of copra meal; (b) diet with 80 per cent of copra meal; (c) diet with 85 per cent of copra meal.

### *High proportion of copra meal II*

Macy and Mendel (1920) found that the toxic property of cotton seed meal varies "according to the condition of seed, variety, soil, climate, and process of manufacture." Similar observations were also noted by other investigators.

"Soil, climate, and variety" would be hard to ascertain with copra meal, inasmuch as no particular attention has been taken to classify them. The types of copra meal on the market vary according to the method of oil extraction used. They are principally expeller product or hydraulic product. Analysis of copra meal I (table 1) shows that its oil content is high. It may then be possible that the effects produced were due to this content.

The first series of experiments was repeated in exactly the same manner as described in preceding paragraphs. Copra meal II was substituted for copra meal I.

*Copra meal, 85 per cent.* A pair of animals, No. 51 ♂ and No. 52 ♀ were, given ration 3, together with liberal amounts of tomato juice. Animal No. 51 ♂ was normal for about a week. In the second week it entered a period of inactivity and quietness which continued to the third week; feces became sticky, hair grew rough, constipation set in and the animal died after 34 days under experiment. Animal No. 52 ♀ was normal for a period of one week, then it also became quiet and inactive in the second week. At the end of the second week, paralysis of the hind quarters was observed. The animal at first took food readily, but later refused it altogether and died after 16 days under experiment.

*Copra meal, 80 per cent.* A pair of animals, No. 49 ♀ and 50 ♂, was given ration 2 and supplied with liberal amounts of tomato juice. Animal No. 49 ♀ stayed normal for a week. The feces then became sticky and foul smelling. At the end of the third week, the animal showed total paralysis of the hind quarters, and died after 17 days. This animal was observed to take in food to the end, but lost in weight from the beginning. Animal No. 50 ♂ stayed normal for a period of two weeks. The feces then began to be sticky and in the third week diarrhea developed. During the fourth week, emaciation and weakness were shown. Blood was thrown with the urine and the animal died after 38 days under experiment.

*Copra meal, 75 per cent.* Two other animals, No. 48 ♂ and No. 47 ♀, were given ration 1 together with liberal amounts of tomato juice. The animals lived very much longer than the animals in the other two lots. Animal No. 48 ♂ stayed normal for a week or so. The feces then began to be sticky; the inactivity of the animal became marked; later, diarrhea developed. The animal's back became highly arched, and later, weakness, emaciation, and constipation set in. The animal died after 42 days. Animal No. 47 ♀ was normal for a week. Then it entered a period of inactivity accompanied by slight diarrhea. Emaciation became apparent and the animal moved with a staggering gait showing no co-ordination of the muscles. The animal died after 22 days. Both animals, as in the other two lots, increased in weight for a week or so, but later on, declined until both finally died. Increased administration of tomato juice, in all cases, failed to either retard or check the development of this sickness.

#### *Copra meal at low percentage*

There is a striking agreement in the results obtained by different investigators, which tend to prove the superiority of copra meal as a protein concentrate when a small amount is used. In connection with these studies, it becomes of interest to observe the reactions of animals on a low proportion of copra meal.

Two animals, No. 9 ♀ and No. 10 ♂, were given ration 4 in which copra meal I was used. With the exception of the development of scorbutic symptoms in the sixth and seventh weeks, both animals showed at all times, for a period of seven months, normal growth. They were always very active and healthy.

Two other animals, No. 45 ♂ and No. 46 ♀, were given ration 4 in which copra meal II was used. Both animals from beginning to the end of the experiment were apparently in normal condition and vigor. Animal No. 46 ♀ decreased in weight in the second and third weeks, but assumed fairly satisfactory growth from the fourth week on. Both copra meal I and II, when used to the extent of 37 per cent, promote good health and vigor.

To observe further the validity of this important property of copra meal, four animals, No. 17 ♂ No. 18 ♀, No. 19 ♀, and No. 20 ♂, were given ration 4, together with 4 to 5 cc. of tomato juice a day for each animal. With the exception of animal No. 19 ♀, which had scurvy causing decrease in weight for two weeks, the four animals exhibited fairly normal growth for a period of more than six months. Guinea pig No. 19 ♀ was cured of scurvy by the administration of 10 cc., instead of 5 cc. of tomato juice. Animal No. 19 ♀ gave birth to young near the end of this experiment. In general, it may be stated that all the four animals manifested good health, vigor, and activity through the period of the experiment. (See chart 3.)

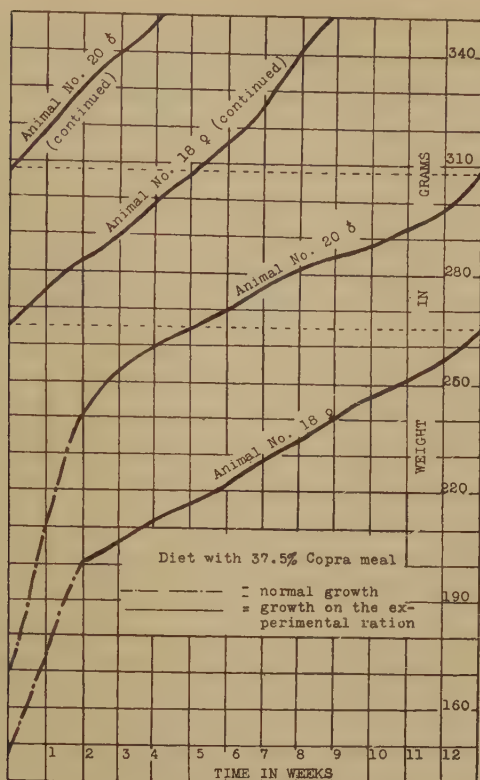


Chart 3.—Typical weight curves of male and female guinea pigs showing their behavior for a period of several months on a diet containing all the necessary food elements in sufficient amounts, but in which there was only 37.5 per cent of copra meal.

*Development of scurvy.* The two animals, No. 9 ♀ and No. 10 ♂, on ration 4 were observed on several occasions to develop scorbutic symptoms which disappeared on increasing the tomato juice. They would, at times, refuse to eat, would sit or lie on one of the hind legs, refuse to walk, and would squeal when touched. These same peculiarities were shown by animal No. 19 ♀, while sick with scurvy.

These characteristic scorbutic tendencies were not shown by any of the animals that were given large proportions of copra meal, which distinctly shows that they died from causes other than scurvy. Besides, the liberal administration of tomato juice which cured animals No. 9 ♂ and No. 10 ♂ and No. 19 ♀, did not benefit the others physiologically.

The results of the experiments show that causes other than scurvy were at work. They also indicate the presence of vitamin C in copra meal.

#### DISCUSSION OF RESULTS.

Table 2 shows the duration of life, the total food intake, the loss or gain in weight of the twelve animals. It may be seen that the average daily food intake of the animals that died was higher than either those of the control or those that were given ration 4. This record indicates that the animals did not die of

starvation. It may, however, be seen that there is no relation between the duration of life of the animals and the amount of copra meal used. The guinea pigs that were given 75 per cent copra meal lived longer than those animals that were fed rations containing 80 per cent and 85 per cent copra meal. The same may be said of the percentage of losses in body weight of the eight animals.

TABLE 2

*Showing the duration of life, total food intake, and loss or gain in weight of the animals during the period of experiments on copra meal I*

| ANIMAL   | RATION | DURATION | FOOD<br>INTAKE | INITIAL<br>WEIGHT | WEIGHT<br>AFTER | GAIN  | LOSS  | REMARKS |
|----------|--------|----------|----------------|-------------------|-----------------|-------|-------|---------|
|          |        | days     | grams          | grams             | grams           | grams | grams |         |
| No. 1 ♂  | 2      | 30       | 697            | 238               | 139             | —     | 92    | Died    |
| No. 2 ♀  |        | 33       |                | 261               | 135             | —     | 126   | Died    |
| No. 3 ♀  | 1      | 39       | 704            | 287               | 244             | —     | 43    | Died    |
| No. 4 ♂  |        | 42       |                | 240               | 143             | —     | 97    | Died    |
| No. 5 ♀  | 2      | 31       | 813            | 273               | 170             | —     | 103   | Died    |
| No. 6 ♂  |        | 34       |                | 206               | 151             | —     | 55    | Died    |
| No. 7 ♀  | 3      | 38       | 660            | 244               | 150             | —     | 94    | Died    |
| No. 8 ♂  |        | 34       |                | 189               | 120             | —     | 79    | Died    |
| No. 9 ♀  | 4      | 207      | 3500           | 234               | 529             | 266   | —     | Alive   |
| No. 10 ♂ |        | 207      |                | 259               | 469             | 210   | —     | Alive   |
| No. 11 ♀ | 5      | 207      | 3820           | 263               | 464             | 201   | —     | Alive   |
| No. 12 ♂ |        | 207      |                | 259               | 454             | 195   | —     | Alive   |

The duration of life of the guinea pigs on the three different rations with high percentage of copra meal varied from 30 to 42 days. All of them lost in weight. Those given 37.5 per cent copra meal continued to live and gained more than 100 per cent in their respective body weights. Likewise, the control animals continued to live. Those that received 37.5 per cent of copra meal gained in weight at comparatively faster rates than those on control ration.

It may then be concluded from the results of these experiments that when copra meal constitutes from 30 to 40 per cent of the ration, it is a better promoter of health and vigor and normal bodily functions than a mixture of rice and corn meal. But when used to the extent of from 75 to 85 per cent it is toxic or deleterious to guinea pigs.

It may be seen in table 3 that the animals fed with large amounts of copra meal had a higher daily average food intake than either those on the control ration or those fed with 37.5 per cent copra meal. This shows that the deaths of the other animals were not due to inanition. Comparing the animals of the same sex on rations with high percentages of copra meal, it may be seen that the larger the amount of copra meal in the ration, the greater is the loss in weight and the shorter is the duration of life of the animal. This proves the toxic property of copra meal. The duration of life of the guinea pigs on rations with a high percentage of copra meal, varied from 16 to 42 days. Compared with the control animals, all the animals that were fed with 37.5 per cent copra meal in the ration showed better growth, better health, and greater activity. It is thus shown that copra meal, at low proportion in the ration, does not exert a deleterious effect, but is rather an efficient protein concentrate.

TABLE 3

Showing the duration of life, total food intake, loss or gain in weight of the animals during the period of experiment with copra meal II

| ANIMAL NO. | RATION | DURATION | FOOD INTAKE | INITIAL WEIGHT | WEIGHT AFTER | GAIN  | LOSS  | REMARKS |
|------------|--------|----------|-------------|----------------|--------------|-------|-------|---------|
|            |        | days     | grams       | grams          | grams        | grams | grams |         |
| 43 ♂       | 5      | 70       | 1252        | 225            | 254          | 29    |       | Alive   |
| 44 ♀       |        | 70       |             | 185            | 211          | 26    |       | Alive   |
| 45 ♂       | 4      | 70       | 1374        | 182            | 247          | 65    |       | Alive   |
| 46 ♀       |        | 70       |             | 173            | 230          | 57    |       | Alive   |
| 47 ♀       | 1      | 22       | 651         | 140            | 124          |       | 16    | Died    |
| 48 ♂       |        | 42       |             | 200            | 170          |       | 30    | Died    |
| 49 ♀       | 2      | 17       | 720         | 187            | 155          |       | 32    | Died    |
| 50 ♂       |        | 38       |             | 180            | 162          |       | 18    | Died    |
| 51 ♂       | 3      | 34       | 710         | 211            | 185          |       | 26    | Died    |
| 52 ♀       |        | 16       |             | 177            | 140          |       | 37    | Died    |

The results of these experiments indicate that copra meal II, like copra meal I, is toxic when used to the extent of 75 per cent or more of the ration. At low percentage, amounting to 37.5 per cent of the ration, it is an efficient protein concentrate and promotes better health and vigor than a mixture of rice and corn.

#### SUMMARY OF CONCLUSIONS

When copra meal forms from 75 to 85 per cent of an otherwise complete ration, it is fatally toxic to guinea pigs.

The important symptoms observed are the following: Negative growth, dullness, coarse and rugged hair, highly arched back, sensitiveness to light, regional paralysis, constipation usually followed by diarrhea, blood exudation, profuse or otherwise, with the feces or urine.

Tomato juice in sufficient amount did not prove beneficial.

Both kinds of copra meal used, one high (15 per cent) the other low (5 per cent) in oil content produced similar deleterious effects, which seems to show that the toxic property is not probably due to the oil content.

When present in small percentage in the ration (about 37 per cent), copra meal is promotive of health, vigor, and growth of guinea pigs.

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# INTENSITY AND DISTRIBUTION OF INFECTIOUS DISEASES OF ANIMALS IN THE PHILIPPINES<sup>1</sup>

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The data, herein compiled for the purpose of demonstrating the intensity and distribution of various diseases of animals in the Philippines, were obtained from the records of the Bureau of Agriculture and the clinical reports of the College of Veterinary Science. These records are far from being complete, owing to the small veterinary force employed by the Bureau of Agriculture in its campaign against animal diseases, and the insufficiency of funds available for transportation. The reports from the College of Veterinary Science include the cases that have come under the observation of its clinical staff in Los Baños and neighboring towns, so these reports affect only the statistics for the province of Laguna.

Previous to 1921, only fragmentary records of epizootics could be obtained, so that comprehensive statistics can be made only for the years 1921 to 1924. These statistics include the following diseases named in the order of their importance: *rinderpest*, *anthrax*, *hemorrhagic septicemia*, *surra*, and *foot-and-mouth* disease. Of the other infectious diseases of animals, there are few records available.

## RINDERPEST

It is generally believed that rinderpest was introduced into the Philippines, in 1886-1887, by some carabaos imported from Indo-China for breeding purposes. Some people, however, claim with insistence, that its introduction dates back to 1882. Previous to the introduction of the disease our live stock were in a flourishing condition, but since its appearance among our cattle and carabaos there have been tremendous losses in our animal population. Its early scourges were very severe, registering a mortality of 90 per cent, while in later years (1900-1901), the military authorities noted that rinderpest in Luzon killed 50 to 60 per cent of the cattle and carabaos.

The disease is now reported to exist throughout the Philippine Archipelago in an enzoötic form. A great deal of money and time has been spent by the government in the last thirty years in its campaign against this epizootic, but very little headway has been made towards its extermination. Under the present laws and difficult field conditions in which the present campaign has to be conducted, it is a question whether the country can be cleared of rinderpest.

Tables 1, 2, 3, and 4 show the intensity and distribution of rinderpest by years throughout the different provinces. It will be seen that, in 1921, a total of 33,190 cases in carabaos and 12,141 in cattle, with a total mortality of 26,489 carabaos and 9,251 cattle were registered in the Philippines (see table 1).

<sup>1</sup> Read before the 14th scientific meeting of the Los Baños Biological Club, October 29, 1925. Experiment Station contribution No. 336. Received for publication November 12, 1925.

Basing calculations on the very conservative estimate of ₱100 a head, the monetary loss for this year amounted to ₱3,574,000. In 1922, there were recorded a total of 28,953 cases of rinderpest in carabaos and 16,730 cases in cattle with a mortality of 22,371 carabaos and 11,935 cattle (see table 2). At ₱100 a head the monetary loss for 1922 would amount to ₱3,430,600. Table 3 shows that, in 1923, there was a total of 15,734 cases in carabaos and 12,471 in cattle with a mortality of 12,762 carabaos and 10,456 cattle. This represents a monetary loss of ₱2,322,000. For the year 1924, there were 15,314 cases in carabaos and 4,285 cases in cattle with a mortality of 12,052 carabaos and 3,298 cattle. The monetary loss would amount to ₱1,535,000.

These figures show the intensity of rinderpest infection for the four years, beginning January, 1921, to December, 1924. Among carabaos there was a total of 61,622 deaths and 31,644 among cattle. This total of 93,266 animals represents the enormous money loss to the Philippines of ₱9,266,600, or an average of ₱2,331,650 annually, caused by rinderpest alone.

#### ANTHRAX

Among the most serious epizootics prevalent in the Philippines, anthrax is second to rinderpest. No statistics could be obtained on this disease in 1921. For the succeeding two years, anthrax was apparently insignificant (see tables 2 and 3). A sudden increase in its severity was reported in 1924, when 3,298 cases in carabaos and 58 in cattle, with a mortality of 3,335 carabaos and 52 cattle were registered. It is possible that, heretofore, many cases of anthrax were mistaken for rinderpest because of failure to distinguish these two diseases.

There is evidence that anthrax was prevalent in these Islands in the nineteenth century. Gines Geis Gotzens, a Spanish army veterinarian, first reported the existence of anthrax in 1887 in his memoirs to the military government. The presence of this disease in the Philippines is also reported as early as 1888 in the eighth and ninth annual reports of the United States Department of Agriculture. Apparently, there occurred a period of dormancy in its infectivity, because as far as I can determine no further records were made regarding anthrax until 1904. In January, 1904, McMullen, formerly connected with the Government laboratories at Manila, suspected the presence of the disease in the town of Tagudin, Ilocos Sur. And in April, 1924, Doctor Lusk, an army veterinarian, reported the death of two mules from anthrax at Camp Wallace, La Union. In the files of the Bureau of Agriculture, there is official correspondence referring to the existence of anthrax in the towns of Bauco and Cayan, sub-province of Lepanto, Mountain Province, and in Sual, Pangasinan. In 1910, Doctor Boynton, former government veterinary pathologist, conclusively proved an anthrax outbreak in Taytay, Rizal by finding and culturing the *Bacterium anthracis* and by reproducing the disease in laboratory animals.

The total monetary loss suffered by the Philippines during the years 1922-1924 from anthrax amounted to ₱338,700 (see table 5).

#### HEMORRHAGIC SEPTICEMIA

Hemorrhagic septicemia is among the fatal diseases prevalent in the Philippines. According to information obtained from Doctor Youngberg, Acting Director of the Bureau of Agriculture, it is not certain when and how this disease was introduced into the Islands. It was discovered in Manila in 1903 and in

the province of Occidental Negros in 1904, and in Bulacan Province in 1905. The severest outbreak occurred in 1924 when 1,070 cases in carabaos and 47 in cattle were recorded (see table 4). As with anthrax, it is possible that many cases of hemorrhagic septicemia have been reported as cases of rinderpest, because of failure to perform a correct differential diagnosis.

The total monetary loss from this disease from 1921 to 1924 amounts to ₱142,200 (see table 5).

#### SURRA

The introduction of surra into the Philippines is of recent occurrence. According to Doctor Musgrave, Doctor Jobling, formerly of the Bureau of Science, was the first man to actually observe the trypanosomes of surra in the horse in the Philippines. Musgrave also states that surra was not present in these Islands before May or June, 1901, nor could it have been introduced from China since the epizootic is unknown there.

In May, 1901, according to available records, a lot of twenty-six horses was received from Australia, some of which went to the Pasay Race Track. It was noticed that one of the seven horses received on May 4 at the stables of the race track was sick, it later died of what is now known as surra. A race horse was the next animal known to be infected from the Pasay Race Track stabled at Calle Uli-Uli. This animal died from the disease. Two other horses from the same stables developed surra and subsequently died from it. One of these horses for some weeks before its death was stabled in Malate and was treated at the former pony corral in Intramuros. About this time, the cavalry horses at Pasay, in the pony corral in Intramuros, and in the stables in Malate were found to be sick from surra.

Just how surra spread in the period between 1901 to 1924, from Manila to Ilocos Norte in the northern part of Luzon and to the south in Zamboanga and Misamis in Mindanao and in the intervening regions, can not be positively told. It is, however, known that no systematic control of the disease was attempted at its first appearance. The records at our disposal do not reveal the real surra situation in the Philippines. Table 5 shows a total of 398 cases of surra in horses and 388 deaths for the four years from 1921 to 1924. There are undoubtedly numerous cases not discovered. As far as I know, there is no systematic campaign for the eradication of this disease in operation at the present time. This disease constitutes the greatest obstacle in the development of the horse industry in the Philippines.

It has been found that cattle and carabaos can harbor the trypanosomes of surra in their blood for two or three years without apparently suffering from any effect. Obviously, these animals constitute dangerous carriers of the infection.

Recently Doctor Kelser of the United States Army Research Department who is at present doing research work on surra in the Bureau of Science, in Manila, has found by means of the complement fixation test, a large number of carabaos and cattle in Laguna chronically infected with surra. This is the first time that this test has been performed for the detection of surra in the Philippines, so far as I know.

The effective control of dourine, a disease similar to surra, in the United States was made possible by the extensive application of this test, together with

proper sanitary measures. If money were available, a similar system of control could be established in these Islands against surra.

#### FOOT-AND-MOUTH DISEASE

How foot-and-mouth disease was introduced into these Islands is not definitely known. The earliest mention in official records is that this disease was reported in 1905 from nearly every province, as well as in Manila. It is probable that this disease was introduced during the early part of the military government, at the time when beef cattle were imported for the army from Hongkong and other Chinese ports.

Fortunately, the epizootic of foot-and-mouth disease in the Philippines is not so severe as it is in the United States. Our carabaos and cattle are quite resistant to its infection. From 1921 to 1924, there were registered a total of 478 cases in carabaos and 562 cases in cattle with a total mortality of only 89 carabaos and 46 cattle. This represents a total monetary loss of ₱13,500 (see table 5).

#### SUMMARY AND DISCUSSION

Table 5 presents a summary of all cases and deaths among carabaos, cattle, and horses in the Philippines from *rinderpest*, *anthrax*, *hemorrhagic septicemia*, *surra*, and *foot-and-mouth* disease during the years 1921 to 1924. Assuming as an index of the degree of infection, the combined totals of cases and deaths from all these diseases, it will be noted that the provinces of Antique, Batangas, Bohol, Bulacan, Capiz, Iloilo, Masbate and Nueva Ecija are the most highly infected. Second to these are, Bataan, Cagayan, Cavite, Cebu, Ilocos Norte, Isabela, Laguna, Mindoro, Nueva Vizcaya, Occidental Negros, Pampanga, Pangasinan, Rizal, Samar, Sorsogon, Tarlac, Tayabas, and Zambales.

These provinces are grouped in two areas of commercial activity, one located in central Luzon with Manila as the center, and the other in the central part of the Visayan Islands with Iloilo as the center. The history of infectious diseases has demonstrated that epidemics as well as epizootics are spread throughout the world, through commercial routes and by invading armies during wars. In a country, as the Philippines, where no system of fencing is practiced or enforced, the spread of an animal disease is very rapid, once it is introduced. Our animals in the fields run loose a great deal of the time and forage for themselves. Herds mingle with herds with the most perfect freedom. Thus infectious diseases, such as rinderpest, may be transmitted in a mild form for a considerable length of time unnoticed, until conditions are favorable for a more or less severe outbreak. The animals drawing our bull carts, which travel 50 to 60 kilometers in transporting agricultural products, have been blamed for the outbreaks of rinderpest which occur along the commercial highways at the height of the annual crop-moving season. Wild animals, such as deer and wild hogs contribute greatly in keeping alive the virus of infectious diseases.

Attention should be called to the imperative necessity of establishing an effective system of quarantine in Mindanao. In the not distant future, this island should become a great center of animal industry. Rinderpest, anthrax, hemorrhagic septicemia, surra and foot-and-mouth disease have been reported to exist in the provinces of Zamboanga, Misamis, Lanao, Agusan, and Surigao although not in alarming proportions (see table 5). As years go by and more com-

mercial routes are opened into the undeveloped territory of these provinces, unless preventive measures are taken, animal diseases are sure to be introduced among the herds of cattle that are now rapidly multiplying on its ranges, such as those of Bukidnon and Lanao. It is imperative that the present foci of infection in this great island be stamped out and the further introduction of animal diseases be effectively guarded against, that the history of epizootics in Luzon and the Visayan islands be not repeated.







TABLE 2

Total cases and deaths from various diseases (From January 1 to December 31, 1922)

| PROVINCES              | RINDERPEST |        |          |        | ANTHRAX  |        |          |        | HEMOR. SEPTICEMIA |        |          |        | FURRA    |        | FOOT-AND-MOUTH |        |          |        |
|------------------------|------------|--------|----------|--------|----------|--------|----------|--------|-------------------|--------|----------|--------|----------|--------|----------------|--------|----------|--------|
|                        | Cases      |        | Deaths   |        | Cases    |        | Deaths   |        | Cases             |        | Deaths   |        | Cases    |        | Cases          |        | Deaths   |        |
|                        | Carabaos   | Cattle | Carabaos | Cattle | Carabaos | Cattle | Carabaos | Cattle | Carabaos          | Cattle | Carabaos | Cattle | Carabaos | Cattle | Carabaos       | Cattle | Carabaos | Cattle |
| Abra.....              | 39         | 20     | 23       | 11     |          |        |          |        |                   |        | 14       | 14     |          |        |                |        |          |        |
| Antique.....           | 5,629      | 5,391  | 3,403    | 3,055  |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Bataan.....            | 446        | 28     | 339      | 24     |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Batangas.....          | 136        | 860    | 121      | 635    |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Bohol.....             | 1,775      | 1,654  | 1,512    | 1,294  |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Bulacan.....           | 1,390      | 119    | 1,260    | 105    |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Cagayan.....           | 473        | 113    | 345      | 78     |          |        |          |        |                   |        | 6        | 6      |          |        |                |        |          |        |
| Camarines Sur.         | 1          | 28     | 1        | 23     |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Capiz.....             | 1,897      | 414    | 1,387    | 326    |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Cavite.....            | 726        | 498    | 687      | 449    |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Cebu.....              | 364        | 450    | 306      | 357    |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Ilocos Norte.....      | 464        | 180    | 353      | 93     |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Iloilo.....            | 5,165      | 2,528  | 3,850    | 1,757  |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Isabela.....           | 249        | 72     | 164      | 59     |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Laguna.....            | 1,492      | 604    | 1,302    | 548    | 34       | 7      | 27       | 14     |                   |        | 3        | 3      |          |        | 208            | 66     | 60       | 2      |
| Lanao.....             |            |        |          |        |          |        |          |        |                   |        |          |        |          |        | 76             | 26     |          |        |
| La Union.....          |            |        |          |        |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Leyte.....             | 11         |        | 10       |        |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Manila.....            | 7          | 25     | 4        |        |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Masbate.....           | 2,629      | 2,176  | 2,534    | 1,872  |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Misamis.....           | 39         | 2      | 33       | 4      |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Mountain Province..... | 309        |        | 173      |        |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Nueva Ecija.....       | 982        | 103    | 736      | 80     |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Nueva Vizcaya.....     | 129        | 14     | 100      | 8      |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Occidental Negros..... | 1,212      | 571    | 1,031    | 453    |          |        |          |        |                   |        | 10       | 10     |          |        | 44             | 282    | 18       | 20     |
| Oriental Negros.....   | 1,193      | 166    | 148      | 153    |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Pampanga.....          | 267        | 4      | 213      | 2      |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Pangasinan.....        | 383        | 139    | 224      | 67     |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Rizal.....             | 1,554      | 253    | 1,374    | 224    |          |        |          |        |                   |        | 1        | 1      |          |        |                |        |          |        |
| Sorsogon.....          | 5          | 27     | 3        | 21     |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Tarlac.....            | 223        | 1      | 175      | 3      |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Tayabas.....           | 28         | 17     | 22       | 16     |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Zambales.....          | 736        | 273    | 458      | 196    |          |        |          |        |                   |        |          |        |          |        |                |        |          |        |
| Zamboanga.....         |            |        |          |        |          |        |          |        |                   |        | 16       | 16     |          |        |                |        |          |        |
| Total.....             | 28,953     | 16,730 | 22,371   | 11,935 | 34       | 7      | 27       | 14     | 0                 | 0      | 0        | 0      | 1        | 50     | 385            | 374    | 78       | 22     |



TABLE 3

Total cases and deaths from various diseases (from January 1 to December 31, 1923)

| PROVINCES              | RINDERPEST |        |          |        | ANTHRAX  |        |                |        | HEMOR. SEPTICEMIA |                |                 |                | SURRA |        | FOOT-AND-MOUTH |        |
|------------------------|------------|--------|----------|--------|----------|--------|----------------|--------|-------------------|----------------|-----------------|----------------|-------|--------|----------------|--------|
|                        | Cases      |        | Deaths   |        | Cases    |        | Deaths         |        | Cases             |                | Deaths          |                | Cases |        | Cases          |        |
|                        | Carabaos   | Cattle | Carabaos | Cattle | Carabaos | Cattle | Carabaos       | Cattle | Carabaos          | Cattle         | Carabaos        | Cattle         | Cases | Deaths | Cases          | Deaths |
| Abra.....              | 11         | 4      | 4        | 3      |          |        |                |        |                   |                |                 |                | 38    | 36     |                |        |
| Albay.....             | 28         | 9      | 9        | 5      |          |        |                |        |                   |                |                 |                | 73    | 73     |                |        |
| Antique.....           | 314        | 459    | 205      | 345    |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Agusan.....            |            |        |          |        |          |        |                |        | 14                | 8 <sup>a</sup> | 14              | 7 <sup>a</sup> |       |        |                |        |
| Bataan.....            | 442        | 91     | 383      | 82     |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Batangas.....          | 1,074      | 6,530  | 920      | 5,203  |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Bohol.....             | 270        | 346    | 217      | 325    |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Bulacan.....           | 4,888      | 521    | 4,128    |        |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Cagayan.....           | 320        | 47     | 209      | 29     |          |        |                |        | 49                |                | 49              |                | 3     | 3      |                |        |
| Canarines Norte.....   | 82         | 1      | 76       | 1      |          |        |                |        |                   |                |                 |                | 1     | 1      |                |        |
| Canarines Sur.....     | 21         |        | 12       |        |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Capiz.....             | 54         | 4      | 37       | 3      |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Cavite.....            | 271        | 139    | 241      | 137    | 18       |        | 18             |        |                   |                |                 |                |       |        |                |        |
| Cebu.....              | 14         | 20     | 6        |        |          |        |                |        | 52                |                | 49              |                |       |        |                |        |
| Iloilo.....            | 260        | 256    | 203      | 193    |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Isabela.....           | 115        | 13     | 95       | 12     |          |        |                |        |                   |                |                 |                | 1     | 1      |                |        |
| Laguna.....            | 206        | 240    | 188      | 179    | 23       | 34     | 17             | 14     |                   |                |                 |                | 67    | 61     | 45             | 3      |
| Lanao.....             |            |        |          |        |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Manila.....            |            | 1      |          |        |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Masbate.....           | 881        | 817    | 871      | 723    |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Mindoro.....           | 1,145      | 2,031  | 1,413    | 2,026  |          |        |                |        | 2                 |                | 2               |                |       |        |                |        |
| Misamis.....           |            |        |          |        |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Mountain Province..... | 1          |        | 1        |        |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Nueva Ecija.....       | 989        | 16     | 741      | 12     |          |        |                |        | 241               |                | 241             |                |       |        |                |        |
| Nueva Vizcaya.....     | 46         | 6      | 40       | 2      |          |        |                |        |                   |                |                 |                | 9     | 7      |                |        |
| Occidental Negros..... | 118        | 8      | 87       | 13     |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Oriental Negros.....   | 43         | 6      | 43       | 4      |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Pampanga.....          | 536        | 6      | 478      | 4      |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Pangasinan.....        | 127        | 16     | 109      | 14     |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Rizal.....             | 162        | 13     | 135      | 11     |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Samar.....             | 68         |        | 44       |        |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Sorsogon.....          | 954        | 368    | 853      | 283    |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Tarlac.....            | 967        | 66     | 732      | 57     |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Tayabas.....           | 320        | 437    | 275      | 351    |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Zambales.....          | 7          |        | 7        |        |          |        |                |        |                   |                |                 |                |       |        |                |        |
| Totals.....            | 15,734     | 12,471 | 12,762   | 10,458 | 41       | 34     | 3 <sup>f</sup> | 14     | 358               | 8              | 35 <sup>f</sup> | 7              | 192   | 182    | 45             | 3      |

<sup>a</sup>Seven of the cases and six deaths are horses.



TABLE 4  
Total cases and deaths from various diseases (from January 1 to December 31, 1924)

| PROVINCES              | RINDERPEST |        |          |        | ANTHRAX  |        |          |        | HEMOR. SEPTICEMIA |        |          |        | SURRA |        | FOOT-AND-MOUTH |        |
|------------------------|------------|--------|----------|--------|----------|--------|----------|--------|-------------------|--------|----------|--------|-------|--------|----------------|--------|
|                        | Cases      |        | Deaths   |        | Cases    |        | Deaths   |        | Cases             |        | Deaths   |        | Cases |        | Deaths         |        |
|                        | Carabaos   | Cattle | Carabaos | Cattle | Carabaos | Cattle | Carabaos | Cattle | Carabaos          | Cattle | Carabaos | Cattle | Cases | Deaths | Carabaos       | Cattle |
| Abra.....              |            |        |          |        |          |        |          |        |                   |        |          |        |       |        |                |        |
| Agusan.....            |            |        |          |        |          |        |          |        |                   |        |          |        |       |        |                |        |
| Albay.....             |            |        | 4        |        |          |        |          |        |                   |        |          |        |       |        |                |        |
| Bataan.....            | 47         |        | 39       |        | 427      | 1      | 364      | 1      |                   |        |          |        | 6     | 6      |                |        |
| Batangas.....          | 166        | 1,514  | 136      | 1,136  |          |        |          |        |                   |        |          |        |       |        |                |        |
| Bohol.....             |            | 2      |          |        |          |        |          |        |                   |        |          |        |       |        |                |        |
| Bulacan.....           | 739        | 42     | 567      | 33     | 2017     | 19     | 1714     | 15     |                   |        |          |        |       |        |                |        |
| Camarines Sur.....     | 109        | 1      | 103      |        |          |        |          |        |                   |        |          |        |       |        |                |        |
| Cagayan.....           | 194        | 48     | 162      | 29     |          |        |          |        |                   |        |          |        |       |        |                |        |
| Cavite.....            | 42         | 10     | 41       |        | 12       |        | 11       |        |                   |        |          |        |       |        |                |        |
| Cebu.....              |            |        |          |        |          |        |          |        |                   |        |          |        |       |        |                |        |
| Ilocos Sur.....        |            |        |          |        |          |        |          |        |                   |        |          |        |       |        |                |        |
| Iloilo.....            | 335        | 232    | 215      | 157    |          |        |          |        |                   |        |          |        |       |        |                |        |
| Isabela.....           | 286        | 56     | 263      | 50     |          |        |          |        |                   |        |          |        |       |        |                |        |
| Laguna.....            | 199        | 28     | 172      | 25     | 34       | 26     | 31       | 25     |                   |        |          |        |       |        |                |        |
| La Union.....          | 5          | 1      | 1        |        |          |        |          |        |                   |        |          |        |       |        |                |        |
| Leyte.....             |            |        |          |        |          |        |          |        |                   |        |          |        |       |        |                |        |
| Manila.....            | 5          |        | 3        |        | 2        |        | 2        |        |                   |        |          |        |       |        |                |        |
| Mindoro.....           | 209        | 116    | 200      | 116    |          |        |          |        |                   |        |          |        |       |        |                |        |
| Mountain Province..... | 19         |        | 15       |        |          |        |          |        |                   |        |          |        |       |        |                |        |
| Nueva Ecija.....       | 6,495      | 369    | 5,084    | 361    | 82       | 71     |          |        |                   |        |          |        |       |        |                |        |
| Nueva Vizcaya.....     | 267        | 176    | 204      | 113    |          |        |          |        |                   |        |          |        |       |        |                |        |
| Occidental Negros..... | 567        | 380    | 304      | 217    |          |        |          |        |                   |        |          |        |       |        |                |        |
| Oriental Negros.....   | 129        | 96     | 100      | 67     |          |        |          |        |                   |        |          |        |       |        |                |        |
| Pampanga.....          | 638        | 2      | 471      |        | 253      | 2      | 223      | 2      |                   |        |          |        |       |        |                |        |
| Pangasinan.....        | 833        | 190    | 653      | 127    | 50       | 1      | 48       | 1      |                   |        |          |        |       |        |                |        |
| Rizal.....             | 519        | 53     | 413      | 46     | 569      | 8      | 471      | 7      | 4                 |        |          |        |       |        |                |        |
| Sorsogon.....          | 358        | 165    | 330      | 140    |          |        |          |        |                   |        |          |        |       |        |                |        |
| Tarlac.....            | 1,578      | 14     | 1,193    | 12     | 434      | 1      | 395      | 1      |                   |        |          |        |       |        |                |        |
| Tayabas.....           | 1,064      | 645    | 963      | 565    |          |        |          |        |                   |        |          |        |       |        |                |        |
| Zambales.....          | 491        | 145    | 416      | 93     |          |        |          |        |                   |        |          |        |       |        |                |        |
| Totals.....            | 15,314     | 4,285  | 12,052   | 3,298  | 3880     | 58     | 3335     | 52     | 984               | 47     | 984      | 41     | 110   | 110    |                |        |



Total cases and deaths from various diseases in four years—1921-1924

| PROVINCES              | RINDERPEST |        |          |        | ANTHRAX  |        |          |        | HEMOR. SEPTICEMIA |        |          |        | SURRA    |        | FOOT-AND-MOUTH |        |    |    | TOTALS  |
|------------------------|------------|--------|----------|--------|----------|--------|----------|--------|-------------------|--------|----------|--------|----------|--------|----------------|--------|----|----|---------|
|                        | Cases      |        | Deaths   |        | Cases    |        | Deaths   |        | Cases             |        | Deaths   |        | Cases    |        | Deaths         |        |    |    |         |
|                        | Carabaos   | Cattle | Carabaos | Cattle | Carabaos | Cattle | Carabaos | Cattle | Carabaos          | Cattle | Carabaos | Cattle | Carabaos | Cattle | Carabaos       | Cattle |    |    |         |
|                        |            |        |          |        |          |        |          |        |                   |        |          |        |          |        |                |        |    |    |         |
| Abra.....              | 153        | 57     | 64       | 35     |          |        |          |        |                   |        |          |        | 52       | 50     |                |        |    |    | 411     |
| Albay.....             | 64         | 9      | 35       | 5      |          |        |          |        |                   |        |          |        | 79       | 79     |                |        |    |    | 359     |
| Antique.....           | 8,392      | 8,195  | 5,281    | 4,827  |          |        |          |        | 46                | 1      | 40       | 1      |          |        |                |        |    |    | 26,695  |
| Agusan.....            |            |        |          |        |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 109     |
| Bataan.....            | 1,321      | 186    | 1,104    | 171    | 427      | 1      | 364      | 1      |                   |        |          |        |          |        |                |        |    |    | 3,575   |
| Batangas.....          | 1,395      | 8,969  | 1,190    | 7,026  |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 18,580  |
| Bohol.....             | 5,665      | 2,281  | 4,772    | 1,894  |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 14,612  |
| Bulacan.....           | 8,576      | 779    | 7,179    | 644    | 2017     | 19     | 1714     | 15     |                   |        |          |        |          |        |                |        |    |    | 20,943  |
| Cagayan.....           | 1,388      | 231    | 1,025    | 153    |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 2,897   |
| Camarines Norte.....   | 173        | 10     | 134      | 2      |          |        |          |        | 49                |        | 49       |        |          |        |                |        |    |    | 417     |
| Camarines Sur.....     | 248        | 52     | 200      | 26     |          |        |          |        | 173               | 1      | 173      | 1      | 17       | 17     | 57             | 8      |    | 2  | 975     |
| Capiz.....             | 7,186      | 2,348  | 5,897    | 1,885  |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 17,316  |
| Cavite.....            | 1,657      | 1,040  | 1,506    | 950    | 30       | 18     | 11       |        |                   |        |          |        |          |        |                |        |    |    | 5,212   |
| Cebu.....              | 3,048      | 897    | 2,681    | 731    |          |        |          |        | 56                | 2      | 53       | 2      |          |        |                |        |    |    | 7,470   |
| Ilocos Norte.....      | 550        | 182    | 432      | 95     |          |        |          |        |                   |        |          |        | 3        | 3      |                |        |    |    | 1,265   |
| Ilocos Sur.....        | 3          | 3      | 3        | 2      |          |        |          |        | 12                | 11     | 12       | 11     |          |        |                |        |    |    | 57      |
| Iloilo.....            | 12,979     | 5,731  | 9,734    | 4,134  |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 32,578  |
| Isabela.....           | 896        | 166    | 720      | 138    |          |        |          |        |                   |        |          |        | 1        | 1      |                |        |    |    | 1,931   |
| Laguna.....            | 2,747      | 1,064  | 2,489    | 928    | 91       | 67     | 75       | 53     |                   |        |          |        | 87       | 81     | 214            | 16     | 61 | 5  | 7,682   |
| Lanao.....             | 6          | 4      | 4        |        |          |        |          |        |                   |        |          |        |          |        | 76             | 26     |    |    | 310     |
| La Union.....          | 5          | 1      | 1        | 1      |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 110     |
| Leyte.....             | 120        | 14     | 83       | 12     |          |        |          |        | 15                |        | 9        |        |          |        |                |        |    |    | 253     |
| Manila.....            | 41         | 26     | 32       | 24     | 2        |        | 2        |        |                   |        |          |        |          |        |                |        |    |    | 127     |
| Masbate.....           | 5,306      | 5,063  | 4,900    | 4,344  |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 19,630  |
| Mindoro.....           | 1,354      | 2,147  | 1,613    | 2,142  |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 7,402   |
| Misamis.....           | 39         | 2      | 33       | 4      |          |        |          |        | 2                 |        | 2        |        |          |        |                |        |    |    | 631     |
| Mountain Province..... | 335        | 44     | 194      | 37     |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 692     |
| Nueva Ecija.....       | 9,303      | 491    | 7,247    | 454    |          |        |          |        | 41                | 1      | 39       | 1      | 9        | 7      |                |        |    |    | 17,993  |
| Nueva Vizcaya.....     | 569        | 284    | 448      | 184    |          |        |          |        | 241               |        | 241      |        |          |        |                |        |    |    | 1,485   |
| Occidental Negros..... | 5,237      | 1,551  | 3,839    | 1,138  |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 12,820  |
| Oriental Negros.....   | 823        | 742    | 564      | 578    |          |        |          |        | 551               | 9      | 491      | 4      |          |        |                |        |    |    | 2,707   |
| Pampanga.....          | 1,698      | 12     | 1,368    | 6      | 253      | 2      | 223      | 2      |                   |        |          |        |          |        |                |        |    |    | 3,564   |
| Pangasinan.....        | 1,418      | 351    | 1,029    | 211    | 50       | 1      | 48       | 1      |                   |        |          |        | 1        | 1      |                |        |    |    | 3,112   |
| Rizal.....             | 2,490      | 463    | 2,159    | 392    | 569      | 8      | 471      | 7      | 6                 |        | 2        |        |          |        |                |        |    |    | 6,567   |
| Samar.....             | 89         |        | 62       |        |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 151     |
| Sorsogon.....          | 1,317      | 560    | 1,186    | 444    |          |        |          |        | 221               | 23     | 215      | 22     |          |        | 20             | 121    | 8  | 13 | 4,150   |
| Surigao.....           | 30         |        | 23       |        | 434      | 1      | 395      | 1      |                   |        |          |        |          |        | 1              |        |    |    | 886     |
| Tarlac.....            | 2,860      | 81     | 2,188    | 70     |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 5,199   |
| Tayabas.....           | 1,449      | 1,126  | 1,295    | 945    |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 4,815   |
| Zambales.....          | 1,322      | 466    | 936      | 317    |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 3,041   |
| Zamboanga.....         |            |        |          |        |          |        |          |        |                   |        |          |        |          |        |                |        |    |    | 32      |
| Totals                 | 192,252    | 45,628 | 73,651   | 34,949 | 38,73    | 117    | 3303     | 80     | 1463              | 63     | 1370     | 52     | 398      | 388    | 478            | 562    | 89 | 46 | 258,761 |

<sup>a</sup> Seven of the cases and six deaths are horses.



# SUGAR CANE BREEDING IN THE COLLEGE OF AGRICULTURE: IV. TRAINING SUGAR CANE PLANTS FOR CONVENIENT POLLINATION WORK<sup>1</sup>

TORIBIO MERCADO

*Private Assistant in Sugar Cane Breeding*

WITH ONE PLATE

In the work of studying the habits of sugar cane flowers and in artificial, and to some extent, forced natural cross-pollination work with this plant, a ladder or a scaffolding has been used to reach the inflorescence. Using these appliances is rather inconvenient and prevents the hybridizer from observing or treating many plants in a given field. With the object of finding a way of working with sugar cane inflorescence that would be more convenient, the experiment here reported was performed during the early part of the 1925-26 flowering season in the Plant Breeding Nursery of the College of Agriculture, Los Baños, Laguna.

## VARIETIES USED

Two varieties of sugar cane were used in this experiment,—the seedling variety C. A. C. 87, representing the hard slender canes, and the Badila, representing the thick, soft canes. In full bloom, C. A. C. 87 plants are about 5 meters high and the Badila plants, about 4 meters.

## PROCEDURE

Two methods of training the sugar cane plant were tried. The first consisted in digging up the sugar cane stool a month or so before flowering, laying the stalks flat on the ground and then covering the roots and stump with earth. The stalks were kept in place by means of hooked sticks fastened to the ground. In the second method, the stool was not dug up; about two weeks before the emergence of the tips or the arrows, the stalks close to the ground were cut half way through, then they were bent as much as possible without breaking. This bending was done daily until the stalks were lying flat on the ground. Once in this position, they were held securely to the ground with hooked sticks, as in the first method.

## RESULTS

The accompanying illustrations give photographic evidence of the success of the experiment. It was found that plants of the sugar cane varieties used, may be so trained as to have the inflorescence at time of blooming at a height below that of the natural, which is convenient for study of flowers and for pollination operations. There is no reason known at present that would prevent plants of any other variety of sugar cane being so trained. Of the two methods used, the second was found to be the more satisfactory. As to whether or not, training of the plants thus affects the development of the flowers and

<sup>1</sup> Experiment Station contribution No. 337. Experiment planned and directed by Doctor Nemesio B. Mendiola of the Division of Plant Breeding, Department of Agronomy.

seeds, it was found that the anthers of the flowers and the development of the seeds were not affected in any conspicuous way; at least, the flowers were produced, pollination was effected and seeds developed in the inflorescences of the plants treated. It was further observed that the lower portions of the stalks, which were in contact with the ground, rooted into the soil from the root bands of the nodes.

Once the sugar plants are trained to assume any desired height, many other advantages are gained. Inflorescences standing low, whether bagged or not bagged, are less subject to heavy winds, hence have better chances for fuller pollination. When two varieties are planted in alternate hills or in alternate rows and it is desired to have one variety pollinated by the other, one variety may be left untreated and the other may be trained so that when the discharge of pollen grains takes place, the inflorescences intended for females will be in a good position to catch the pollen grains from the male parent plants. Moreover, if it is desired to collect pollen grains from a variety, more pollen grains may be collected from trained plants in the same length of time during pollination than from those standing naturally.

#### EXPLANATION OF PLATE

- Fig. 1. Trained plants of variety Badila which represents thick soft canes.
- Fig. 2. Trained stalk, the inflorescence of which is enclosed in a cage. Note the convenient position of the cage.
- Fig. 3. Trained stalks of variety C. A. C. 87 which represents slender hard canes. Note the difference in height between inflorescences of trained stalks and those of the untrained plants.



Fig. 1



Fig. 2



Fig. 3



# A STUDY OF THE FREQUENCY OF CALVING OF COWS UNDER PHILIPPINE CONDITIONS<sup>1</sup>

VALENTE VILLEGAS

The success and value of a herd of range cattle depend largely upon the capacity of breeding cows to produce calves. Theoretically, the increase of animals on a ranch may be mathematically figured out on the basis of the behavior of breeding cows in small herds. But where the cows are, more or less, in a state of nature as they are on a ranch, their breeding efficiency is likely to differ from that obtaining in small herds.

The frequency of calving of cows is a fair indication of the general fertility of the herd, and the records kept in this connection reveal the infertile, sterile or non-breeding cows. Knowing the average frequency of calving of cows and the total number of fertile animals in the herd, the rate of increase may be determined readily. It is to be regretted that owing to the incompleteness of the data available it is not possible to determine actually the rate of increase of the herds investigated.

## OBJECTS

The objects of this investigation were: (a) To determine the frequency of calving of breeding cows under range conditions; (b) To find out the period elapsing between the last calving and the beginning of the next pregnancy.

## TIME AND PLACES

The data presented in this paper are from records kept at the San Lorenzo Ranch, Mailag, and Nellore Ranch, Lorugan, Malaybalay, Bukidnon, from June 6, 1921, to April 17, 1925.

## MATERIALS

Forty-seven cows on the Nellore Ranch and 32 cows on the San Lorenzo Ranch were used in this investigation, making a total of 79 cows. The records studied include 123 calvings of cows on the Nellore Ranch and 70 calvings of cows on the San Lorenzo Ranch, or a total of 193 calvings. The majority of the cows were half-bred Nellore  $\times$  native, and the rest were native and  $\frac{3}{4}$  Nellore— $\frac{1}{4}$  native. With the exception of a few old native cows, these animals were in excellent breeding condition. They ranged from approximately four to eight years of age.

## SYSTEM OF MANAGEMENT

The cows of the Nellore Ranch belong to a herd of 1,000 head, while those of the San Lorenzo Ranch are from a herd of 500 head. These animals have the freedom of the open pasture, day and night, and subsist on good succulent

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grasses, consisting mostly of young cogon and bagoeboc (*Andropogon nitidus* [Vahl] Kunth). Water is plentifully supplied from flowing streams which cross the pastures.

Young and vigorous Nellore bulls were in the herds at the rate of one bull for every forty to fifty cows.

It was observed that while the animals were grazing they would gather into small groups or scatter singly on the pasture, but at least once a day after having their full feed, or at salting time, they would all come together. Certain bulls would separate from the rest of the animals and graze alone unmolested, then return to the herd.

A herdsman visited each herd every day or once in two days, to salt the animals and look for new births, and to observe the animals for any disease, accident or other irregularities. The cows were numerically branded so that the mother of any calf dropped could be readily identified. Birth reports were made to the superintendent by the herdsman in the evening.

#### INTERVAL BETWEEN CALVINGS

As may be seen in table 1, the interval between calvings of cows on Nellore Ranch ranged from 305 to 500 days, giving an average of 361.5 days. Table 4 shows that about 58 per cent of the cows on this ranch calved within 301 to 360 days, and about 37 per cent within 301 to 330 days. The rest were distributed as follows: About 16 per cent in 361-390 days; about 11 per cent in 391-420 days; about 13 per cent in 421-450 days; and about 3 per cent in 451 or more days.

Table 2 shows that the interval between calvings of cows on San Lorenzo Ranch varies from 266 to 429 days with an average of 337 days. According to table 4 about 53 per cent of the cows calved between 301 to 360 days. With the rest of the cows the distribution of interval between calvings is as follows: About 13 per cent in 300 days or less; about 16 per cent in 361-390 days; about 5 per cent in 391-420 days; and about 3 per cent in 421-450 days.

It is evident from these averages that the cows on Nellore Ranch calved about 25 days later than did the cows on San Lorenzo Ranch. It is apparent also that no cows on Nellore Ranch calved within 300 days or less, whereas about 13 per cent of the cows on San Lorenzo Ranch calved within that period; 58 per cent of the cows on Nellore Ranch and 53 per cent on San Lorenzo Ranch calved within 301 to 360 days. Forty-two per cent of the cows on Nellore Ranch calved in 361 days or over, while only 24 per cent calved within the same period on San Lorenzo Ranch.

A possible explanation for the breeding efficiency of the cows on San Lorenzo Ranch being better than of those on Nellore Ranch is, that the herd on San Lorenzo Ranch is only half the size of that on Nellore Ranch. Animals of a large herd are likely to segregate into small groups, while those in a small herd stay together. The bulls in a large herd may not distribute themselves well among the different groups, so that cows in heat are not likely to be covered as readily.

Records at the College of Agriculture, Los Baños, indicate that the average interval between calvings of 6 cows, representing 20 calvings, is 369.6 days. Disregarding the record of one cow which gave an exceptionally long interval of 590 days, the average becomes 352.6 days. The interval ranges from 313 to 590 days. (See table 3.)

## REST PERIOD

By rest period as used here is meant the time elapsing from the last calving to the beginning of the next pregnancy. The rest periods shown in tables 1, 2, and 3 were obtained by subtracting the average period of gestation of 280 days from the intervals between calvings. The records here presented are, therefore, only an approximation, not the true rest period.

It will be seen in table 1 that the rest period of cows on Nellore Ranch ranged from 25 to 220 days, giving an average of 81.2 days, or about nine days short of three months.

The rest period of cows on San Lorenzo Ranch, according to table 2, ranged from -14 to 149 days, and averaged 57.1 days, which is about three days short of two months. In the case of the rest period of cow No. 12 of San Lorenzo Ranch, which was -14 days in the second period, the cow must have carried her calf less time than the average period of pregnancy, and probably was bred soon after parturition.

According to table 3, the average rest period of cows at the College of Agriculture, Los Baños, is 89.6 days. If the extraordinarily long rest period of cow Empress is excepted, the average rest period becomes 72.6 days, a figure intermediate between that of the two ranches. The variation ranges from 33 to 310 days.

## SUMMARY

1. This investigation was made with cows of the Nellore Ranch of Lorugan and San Lorenzo Ranch of Mailag, Malaybalay, Bukidnon. The records studied were with calvings from June 6, 1921, to April 17, 1925.

2. In the herds investigated there were about 500 head of cattle at the San Lorenzo Ranch and about 1000 head at the Nellore Ranch. These included breeding cows, bulls, heifers, and calves.

3. Seventy-nine cows were used in this investigation, of which 47 were from Nellore Ranch and 32 from San Lorenzo Ranch. The majority of these cows were half-bred Nellore  $\times$  native. The records include 123 calvings of cows of Nellore Ranch and 70 calvings of cows of the San Lorenzo Ranch, or a total of 193 calvings.

4. An intelligent system of management was followed on the two ranches. The animals had the range of rich, ample pastures and were salted regularly. An adequate number of bulls was placed in the herds.

5. The average interval between calvings with cows on Nellore Ranch was 361.5 days; with cows on San Lorenzo Ranch, the average was 337.1 days. The records at the College of Agriculture average 369.6 days.

6. The average rest period with cows on Nellore Ranch was 81.2 days, on the San Lorenzo Ranch, 57.1 days. At the College of Agriculture, the average rest period is 89.6 days.



TABLE 1

*Showing the interval between calvings and the rest period of breeding cows on Nellore Ranch, Bukidnon*

TABLE 2

*Showing the interval between calvings and the rest period of breeding cows on San Lorenzo Ranch, Bukidnon*

| COW NO. | INTERVAL BETWEEN CALVINGS | REST PERIOD | COW NO. | INTERVAL BETWEEN CALVINGS | REST PERIOD |
|---------|---------------------------|-------------|---------|---------------------------|-------------|
|         | days                      | days        |         | days                      | days        |
| 1       | 423                       | 143         | 1       | 366                       | 86          |
| 1       | 342                       | 62          | 2       | 329                       | 49          |
| 2       | 411                       | 131         | 3       | 339                       | 59          |
| 2       | 346                       | 66          | 4       | 326                       | 46          |
| 3       | 322                       | 42          | 5       | 354                       | 74          |
| 3       | 401                       | 121         | 6       | 286                       | 6           |
| 4       | 324                       | 44          | 7       | 312                       | 32          |
| 5       | 443                       | 163         | 7       | 328                       | 48          |
| 6       | 363                       | 83          | 8       | 327                       | 47          |
| 6       | 500                       | 220         | 9       | 324                       | 44          |
| 7       | 361                       | 81          | 9       | 344                       | 64          |
| 8       | 372                       | 92          | 10      | 312                       | 32          |
| 9       | 353                       | 73          | 11      | 309                       | 29          |
| 10      | 333                       | 53          | 12      | 347                       | 67          |
| 11      | 450                       | 170         | 12      | 266                       | -14         |
| 12      | 320                       | 40          | 13      | 292                       | 12          |
| 13      | 307                       | 27          | 13      | 331                       | 51          |
| 13      | 335                       | 55          | 14      | 366                       | 86          |
| 14      | 435                       | 155         | 15      | 351                       | 71          |
| 14      | 394                       | 114         | 16      | 366                       | 86          |
| 15      | 422                       | 142         | 17      | 294                       | 14          |
| 16      | 318                       | 38          | 18      | 355                       | 75          |
| 16      | 321                       | 41          | 19      | 319                       | 69          |
| 17      | 401                       | 121         | 20      | 333                       | 53          |
| 18      | 385                       | 105         | 21      | 367                       | 87          |
| 19      | 319                       | 39          | 22      | 365                       | 85          |
| 19      | 367                       | 87          | 23      | 429                       | 149         |
| 20      | 339                       | 59          | 24      | 416                       | 136         |
| 21      | 327                       | 47          | 24      | 324                       | 44          |
| 21      | 373                       | 93          | 25      | 314                       | 34          |
| 22      | 396                       | 116         | 26      | 309                       | 29          |
| 23      | 413                       | 133         | 26      | 334                       | 54          |
| 23      | 374                       | 94          | 27      | 385                       | 105         |
| 24      | 314                       | 34          | 28      | 325                       | 44          |
| 24      | 347                       | 67          | 29      | 444                       | 134         |
| 24      | 318                       | 38          | 30      | 280                       | 0           |
| 25      | 322                       | 42          | 31      | 322                       | 42          |
| 25      | 358                       | 78          | 32      | 319                       | 39          |
| 26      | 358                       | 78          |         |                           |             |
| 26      | 329                       | 49          | Average | 357.95                    | 57.02       |
| 27      | 416                       | 136         |         |                           |             |
| 27      | 328                       | 48          |         |                           |             |
| 28      | 425                       | 145         |         |                           |             |
| 28      | 347                       | 47          |         |                           |             |
| 29      | 305                       | 25          |         |                           |             |
| 29      | 310                       | 30          |         |                           |             |
| 30      | 331                       | 51          |         |                           |             |
| 30      | 329                       | 49          |         |                           |             |
| 31      | 326                       | 46          |         |                           |             |
| 32      | 463                       | 183         |         |                           |             |
| 32      | 370                       | 90          |         |                           |             |
| 32      | 321                       | 41          |         |                           |             |
| 33      | 431                       | 151         |         |                           |             |
| 34      | 354                       | 74          |         |                           |             |
| 34      | 430                       | 150         |         |                           |             |
| 35      | 320                       | 40          |         |                           |             |
| 35      | 319                       | 39          |         |                           |             |
| 36      | 325                       | 45          |         |                           |             |
| 37      | 319                       | 39          |         |                           |             |
| 38      | 398                       | 118         |         |                           |             |
| 39      | 344                       | 64          |         |                           |             |
| 39      | 321                       | 41          |         |                           |             |
| 40      | 441                       | 161         |         |                           |             |
| 40      | 424                       | 144         |         |                           |             |
| 41      | 358                       | 78          |         |                           |             |
| 42      | 355                       | 75          |         |                           |             |
| 43      | 379                       | 99          |         |                           |             |
| 44      | 312                       | 32          |         |                           |             |
| 44      | 322                       | 42          |         |                           |             |
| 44      | 325                       | 45          |         |                           |             |
| 45      | 364                       | 84          |         |                           |             |
| 45      | 346                       | 66          |         |                           |             |
| 45      | 373                       | 93          |         |                           |             |
| 46      | 362                       | 82          |         |                           |             |
| 47      | 313                       | 33          |         |                           |             |
| 47      | 329                       | 49          |         |                           |             |
| Average | 361.5                     | 81.2        |         |                           |             |



TABLE 3

*Showing the interval between calvings and the rest period of breeding cows at the College of Agriculture, Los Baños, Laguna*

| COW               | BREED                                            | INTERVAL BETWEEN CALVINGS | REST PERIOD |
|-------------------|--------------------------------------------------|---------------------------|-------------|
|                   |                                                  | <i>days</i>               | <i>days</i> |
| Liberty.....      | Native.....                                      | 325                       | 45          |
| Liberty.....      | Native.....                                      | 326                       | 46          |
| Liberty.....      | Native.....                                      | 323                       | 43          |
| Venus.....        | $\frac{1}{2}$ Nellore- $\frac{1}{2}$ Native..... | 417                       | 137         |
| Venus.....        | $\frac{1}{2}$ Nellore- $\frac{1}{2}$ Native..... | 313                       | 33          |
| Cleopatra.....    | Nellore-Native.....                              | 340                       | 60          |
| Cleopatra.....    | Nellore-Native.....                              | 328                       | 48          |
| Cleopatra.....    | Nellore-Native.....                              | 425                       | 145         |
| Cleopatra.....    | Nellore-Native.....                              | 317                       | 37          |
| Cleopatra.....    | Nellore-Native.....                              | 328                       | 48          |
| Independence..... | $\frac{1}{2}$ Nellore- $\frac{1}{2}$ Native..... | 382                       | 102         |
| Independence..... | $\frac{1}{2}$ Nellore- $\frac{1}{2}$ Native..... | 333                       | 53          |
| Prospect.....     | Nellore-Native.....                              | 427                       | 147         |
| Empress.....      | Nellore-Native.....                              | 590                       | 310         |
| Average.....      |                                                  | 369.6                     | 89.6        |

TABLE 4

*Showing the distribution of interval between calvings into periods of 30-day interval, e'tc.*

| PERIODS     | NELLORE RANCH |            | SAN LORENZO RANCH |            |
|-------------|---------------|------------|-------------------|------------|
|             | Frequency     | Percentage | Frequency         | Percentage |
| <i>days</i> |               |            |                   |            |
| 300 or less | —             | —          | 5                 | 13.16      |
| 301-330     | 28            | 36.84      | 14                | 36.84      |
| 331-360     | 16            | 21.05      | 10                | 26.32      |
| 361-390     | 12            | 15.79      | 6                 | 15.79      |
| 391-420     | 8             | 10.53      | 2                 | 5.26       |
| 421-450     | 10            | 13.16      | 1                 | 2.03       |
| 451 or over | 2             | 2.63       | —                 | —          |



## THE NEED OF FUNDS FOR RESEARCH<sup>1</sup>

F. O. SANTOS

*Of the Department of Agricultural Chemistry*

Several years ago, Professor Lafayette B. Mendel of Yale, in introducing Professor F. G. Hopkins of Cambridge University to an audience of scientists, said that when he visited the laboratory of Professor Hopkins, he found it no better equipped than the poorest laboratory in the United States, "but he is one who works with the minimum of equipment and the maximum of brain." The College of Agriculture has been working under hampering conditions not unlike those under which Professor Hopkins labored so efficiently. But when we consider the present progress in science, we find that working with the "maximum of brain," only, is no longer sufficient. In a race between two persons, where one uses the maximum efficiency of his good pair of legs and the other an automobile, the outcome is obvious.

The rapid strides in science made by the United States in the last decade are attributed not only to the efficiency of her brain workers, but also to the excellent facilities offered to these men. Some instances may be cited:

1. The success of the Rockefeller Foundation is due, not only to the brains of the men working under it, but also to the unlimited facilities given.

2. Professors Millikan and Noyes would not be able, probably, to put out the work which they are publishing now, were it not for the modern equipment of the laboratories of the California Institute of Technology at Pasadena.

3. The researches of Professor Richards would not have been possible had it not been for the generous allotment given by Harvard University.

4. The work of Osborne and Mendel might not have been made public had it not been for the liberal appropriations given by Yale University, the Connecticut Agricultural Experiment Station, and the Carnegie Institute at Washington.

5. The work, accorded the Nobel Prize, of Professor Banting and collaborators on insulin at Toronto could hardly have been done without generous appropriation.

6. The success of Professor McCollum, formerly of the University of Wisconsin and now at Johns Hopkins, could not have been attained without the facilities offered him by these two institutions.

7. The work that is now being turned out by Professor Steenbock is greatly aided by the laboratory equipment of the University of Wisconsin. Replying to an offer for appointment in the Chemistry Department in this College, Professor Steenbock in a letter to the writer said:

I am comfortably situated in my present position and have the facilities and means available for the prosecution of experimental work in which I am very much interested. This, in itself, represents a deterrent acting against consideration of your proposition which is not easily counteracted.

<sup>1</sup>Experiment Station contribution No. 339. Received for publication November 6, 1925.

From these illustrations it will be seen that where an institution expects its men to promote science or even keep abreast with the times, the prerequisite "maximum of brain" is not the only desideratum.

The following report on an experiment shows how work may not only be hampered, but only partial success attained because of the lack of even a few pesos. As a member of the Committee on Beriberi Control the writer was asked to compare the keeping quality of unpolished rice with that of polished rice. The Committee had no funds at its disposal although frequent requests for appropriation had been made of the proper authorities. However, this comparison had to be made. Several varieties of rice, both unpolished and polished, were needed. As there was no money to buy any rice, a request was made of the Department of Agronomy of the College of Agriculture for some. This department, through Professor Raymundo, kindly consented to furnish and prepare the materials. But, owing to pressure of work in the department, only three varieties were supplied and these not at the same time, one being received February 11, 1925, and two others July 6, 1925. Credit is due to Professor Raymundo that under the circumstances he was able to furnish these samples.

Table 1 gives the history and table 2 the chemical analysis of these three varieties.

TABLE 1

|                            | HARVESTED        | HULLED ONLY OR POLISHED | AMOUNT                                 |
|----------------------------|------------------|-------------------------|----------------------------------------|
| Hambas (Los Baños)....     | January 31, 1925 | February 10, 1925       | Polished: 3 kgm.<br>Unpolished: 2 kgm. |
| Bulilising (C. A. 5890) .. | January 14, 1925 | July 5, 1925            | Polished: 1 kgm.<br>Unpolished: 1 kgm. |
| Iroy (C. A. 5894).....     | January 13, 1925 | July 4, 1925            | Polished: 1 kgm.<br>Unpolished: 1 kgm. |

TABLE 2

|                                     | HAMBAS (LOS BAÑOS) |                 | BULILISING (C. A. NO. 5896) |                 | IROY (C. A. NO. 5894) |                 |
|-------------------------------------|--------------------|-----------------|-----------------------------|-----------------|-----------------------|-----------------|
|                                     | Polished           | Unpolished      | Polished                    | Unpolished      | Polished              | Unpolished      |
|                                     | <i>per cent</i>    | <i>per cent</i> | <i>per cent</i>             | <i>per cent</i> | <i>per cent</i>       | <i>per cent</i> |
| Moisture .....                      | 13.89              | 13.39           | 14.69                       | 13.37           | 14.13                 | 14.24           |
| Ash.....                            | .56                | 1.64            | 1.20                        | 2.17            | .79                   | 1.61            |
| Protein.....                        | 10.79              | 14.32           | 12.38                       | 12.66           | 12.09                 | 12.84           |
| P <sub>2</sub> O <sub>5</sub> ..... | .29                | .93             | .65                         | .76             | .55                   | .77             |

The work was carried out as follows: The samples were placed in tin cans, covered with boards. They were kept in the writer's office. This office has a cement floor and cement walls, and the ventilation is better than in rice bodegas.

Some of the results of the experiments follow:

1. Only one variety (Hambas) showed a difference in the keeping quality between the polished and unpolished samples.

(a) Hambas: By June 9, 1925 (4 months after it was hulled) the unpolished sample was almost one-third powder, and was lumpy and moldy; if placed on the market, its appearance was such that it would not attract buyers. Both samples were infested with pests and fungi. But the polished sample was still good in appearance, even up to October 1, 1925, when part of it was given to chickens and rest eaten by the writer and his family.

(b) Bulilising: Both samples by September 15 (less than three months after either hulling or hulling and polishing) were moldy and decayed.

(c) Iroy: Both samples by September 15 were in a condition similar to that of Bulilising.

2. Chemical analyses, which were completed some days after the experiment was begun, showed that the samples of Bulilising and Iroy, classified as polished, had not been polished enough. The  $P_2O_5$  of the polished and unpolished samples of both varieties was practically the same. Hence, their keeping quality was similar.

3. No feeding tests were made as the samples obtained were small.

If the author had had the necessary funds the following procedure in the preparation of the samples would have been followed:

1. At least two dozen samples would have been taken.
2. At least one cavan of each would have been used.
3. The samples would have been polished to the same degree.
4. Normal bodega conditions would have been secured for their storage.

Could these provisions have been made, the results should have been satisfactory and valuable. Without funds, in a large measure, the effort and time expended were wasted. Even an unreflecting layman would hardly question the economic value, to say nothing of the humane side, of an experiment, to find ways to prevent and control beriberi.



# GERMINATION OF RICE SEEDS: THE EFFECT OF SOAKING IN WATER AND DELAYED SOWING ON THE RATE PERCENTAGE AND UNIFORMITY OF GERMINATION<sup>1</sup>

BASILIO HERNANDEZ

Accurate knowledge of how to successfully germinate rice seed is important, especially when selected seeds are used and when it is desired to get one hundred per cent germination. Filipino farmers do not seem to agree as to what treatment the seeds of rice should receive before sowing. Some soak the seeds in water for one day and then delay the sowing for two days. Others sow the seeds at once, after soaking in water for about twenty-four hours. There are many other practices different from these two.

It was the object of the present study to determine how long the seeds of rice should be soaked in water and how long sowing should be delayed in order to obtain a high percentage of rapid and uniform germination.

The investigation was carried out in the College of Agriculture. The first set of experiments was started on June 27, 1921, the second set on August 3, 1921, and the third set on September 20, 1921. Each set lasted for a period of twenty-five days. A confirmatory test was carried out in the field of Mr. Pedro L. Ramos in Bay, on August 16, 1921.

## MATERIALS AND METHODS

### *Varieties of rice*

Inintiw and Makan varieties were used. These varieties are both lowland and gave a good yield the year the seed was selected.

### *The soil*

The soil was taken from the orchard back of the Seed Laboratory; as it is clay loam, it is representative of most rice soils. The soil was piled in a heap and mixed thoroughly before putting it in the pots used for germination. The pots were filled with equal amounts of soil. The soil was found to contain 18.23 per cent moisture.

### *Preparation of different soil saturations*

*Saturated.* In each pot, water was slowly poured until the soil became thoroughly wet. Care was exercised that no standing water formed on the surface of the soil in the pot. This soil is here considered *saturated* in water.

*Over-saturated.* To the soil in each pot, water was added slowly until there was about 6 millimeters of standing water on the surface of the soil. This state of saturation is here designated as *over-saturated*.

<sup>1</sup>Thesis presented for graduation, 1921, with the degree of Bachelor of Agriculture, from the College of Agriculture, No. 217, Experiment Station contribution, No. 340. Prepared in the Department of Agronomy, under the direction of Dr. R. B. Espino.

*Under-saturated.* The soil in this set was made barely moist. Only enough water to make the particles of soil cling together was added to each pot. About half as much water as was used in the preparation of saturated soil was used in the preparation of *under-saturated* soil.

#### *Soaking and planting of seeds*

Seeds of each variety were soaked in water for one day. They were then wrapped in a piece of gunny sack and placed in a box to check drying out. One hundred of these seeds were sowed in a pot containing *under-saturated* soil; one hundred in a pot containing *saturated* soil; and one hundred in a pot containing *over-saturated* soil.

At the end of the second, the third, the fourth, and the fifth days, each of another set of three pots containing soil with the same degrees of water saturation as the first, was planted with one hundred seeds. This process was repeated with seeds soaked in water for two days; for three days; for four days; and for five days.

The field test was made as an amplification or confirmation of the results obtained from the pot tests. The same procedure used in pot tests was followed, except that only the *saturated* condition of the soil was used, and one *chupa* (.375+ liters) of rice seeds was sown to each plot of one-third square meter in area.

### EXPERIMENT AND RESULTS

#### *Tests in pots*

The seeds that germinated were observed as to degree of uniformity. The germinated seeds were counted and the percentage determined.

The results of the three trials on germination in pots of the seeds of both Makan and Inintiw were tabulated. These tables are on file in Department of Agronomy in this College. The results are given, in general, under "Discussion of Results."

Observations on field-plot tests were made qualitatively. The seeds that were soaked for 2 days and the sowing delayed for another 2 days gave the best results, as indicated by thick growth of young seedlings; those soaked for 3 days and the sowing delayed 2 days, ranked second; and those soaked for 2 days and sowing delayed for 3 days, ranked third. This was true with both varieties used.

The results also showed that the seeds soaked in water for 4 days, as well as those soaked for 5 days, germinated when soon planted. But the seeds that were sowed after 3 or more days gave poor results.

Irrespective of the length of time of soaking, planting 4 or 5 days after soaking always gave a low percentage of germination. This was true with both Inintiw and Makan varieties.

The seeds used as control, which were not soaked in water before sowing, gave a low percentage of germination.

It was observed that a high percentage of germination was always followed by a uniform stand and a rapid growth of the seedlings.

### DISCUSSION OF RESULTS

#### *Germination of Makan and Inintiw seeds in pots*

*As influenced by saturation.* On an average, the seeds that were sowed in *water-saturated* soil gave the highest percentage of germination and the most rapid and the most uniform of the three degrees of saturation tested. Of the

30 cultures in each set of tests, all the cultures in the *saturated* soil were better than the corresponding cultures in the *under-saturated*. This was true for both varieties. With the Makan variety, 18 cultures in the *saturated* soil were superior to the corresponding cultures in the *over-saturated*. There was quite similar differences with the Inintiw. The *saturated* soil set gave 20 cultures superior to similar cultures in the *over-saturated*. However, the average difference between these states of saturation was very little. It may, therefore, be assumed that the degree of saturation of the soil for optimum germination is probably the *saturated* here tested, or that it lies somewhat between the *saturated* and the *over-saturated*. This is probably explained by the fact that too little water in the soil makes it difficult for the seeds, as well as the seedlings, to get enough moisture from the soil.

On the other hand, too much water in the soil would tend, as was observed, to make germination slow. Such an accumulation of water in the soil always keeps the temperature of the soil low, thus depriving the seeds of heat, one of the essential conditions favoring germination. Moreover, too much water in the soil keeps away the air in it from the seeds. This, again, deprives the seeds of oxygen, another essential condition for germination. This last may not, however, hold true, if the two varieties of rice here studied belong to the same category as the rices that can grow anaerobically, that is, can get along well in life without deriving their supply of free oxygen from the air.

Inasmuch as the prime object of this study was to determine the best method of germinating rice seeds, at least of the two varieties studied, and since the highest percentage, most rapid and uniform germination, was obtained from the tests where the soil was saturated in water, further report will be mainly based on the results obtained from this state of saturation of the soil.

*As influenced by duration of soaking.* The results plainly showed that, of the different lengths of time of soaking tested, the seeds of both Makan and Inintiw varieties soaked in water for two days gave the highest percentage of germination. This high percentage in germination was accompanied by uniform and rapid growth of the young plants.

TABLE 1

*Percentage of germination as influenced by the number of days the seeds were soaked in water*

| NO. OF DAYS | MAKAN           |           |                | ININTIW         |           |                |
|-------------|-----------------|-----------|----------------|-----------------|-----------|----------------|
|             | Under-saturated | Saturated | Over-saturated | Under-saturated | Saturated | Over-saturated |
| 1           | 64.66           | 78.77     | 75.83          | 67.48           | 76.38     | 75.33          |
| 2           | 66.56           | 80.49     | 78.05          | 66.52           | 78.49     | 76.22          |
| 3           | 69.72           | 78.38     | 76.99          | 59.44           | 76.05     | 76.05          |
| 4           | 57.89           | 69.72     | 71.66          | 47.77           | 65.44     | 63.05          |
| 5           | 42.94           | 57.89     | 54.25          | 54.27           | 37.72     | 49.16          |

These results emphasize the importance of knowing the number of days that the seeds should be allowed to remain in the water. Too short or too long soaking was usually accompanied by poor results in germination. The seeds soaked in water for one day gave poor results of germination. This may be explained, probably, by the fact that the young plant in the seed had not yet been well awakened by the limited amount of water that the seeds had a chance to

imbibe. On the other hand, the seeds that were soaked in water for three or more days failed to sprout well. This failure, probably, may be accounted for by the seeds not getting ample supply of oxygen for respiration. Moreover, the accumulation of certain products of decomposition of respiration, such as carbon dioxide, and certain other acids, may have made it difficult for the seeds to germinate well. Furthermore, the seeds when immersed in a body of cold water do not get the amount of heat they require for germination, hence delay and poor stand in sprouting.

*As influenced by delay in sowing.* Accepting the results found that when the soil is *saturated* in water it is most suitable for germination, the question arises as to how long seeds may be allowed to remain immersed in water before planting.

Confining attention to the results of germination in soil *saturated* with water, it may be seen that for both the varieties used and irrespective of the length of time of soaking, the best results were obtained between one and three days delay in planting. An early sowing of the seeds after immersion was always accompanied by a rather low percentage, poor uniformity, and medium rate of germination. Three or more days' delay in sowing resulted in poor results in germination. This was particularly true when the seeds had been soaked in water for more than two days. The most ideal condition for germination seems to be to soak the seeds for about two days; to keep them in a sack for another two days; then plant them.

#### *Field-plot tests*

The results from the field tests seem to wholly confirm those from the *saturated* soil in the pot tests. As in the pot tests, the best development of the young plant was obtained from seeds that were soaked in water for two days and sowed in the plots after another period of two days. The results from the field-plot tests emphasize the accuracy of results from the pot tests.

#### SUMMARY OF CONCLUSIONS

Under the conditions of this study and with the Inintiw and Makan varieties of rice here tested, it appears that a few generalizations may be drawn from the results obtained:

1. That the highest percentage of rapid and uniform germination of the rice seeds was obtained from the tests where the seeds were soaked in water for two days and planted two days afterward.
2. That a greater percentage of germination was obtained when the seed was sowed in soil *saturated* with water, than when it was sowed in *under-saturated* or *over-saturated* soil.
3. That too short a period of soaking failed to provide enough water for the embryo to stimulate its growth. Too long soaking of the seeds in water probably cut short the supply of air needed in respiration by the embryo.
4. That a delay of more than three days in sowing the seeds after removing from water was always followed by a low percentage of germination.

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# COMPARATIVE AMOUNTS OF GASES CARBON DIOXIDE, OXYGEN, AND NITROGEN FOUND IN THE BODY OF CERTAIN PLANTS<sup>1</sup>

SIXTO A. GAERLAN

## INTRODUCTION

In this paper are presented some data on the nature and the amounts of three gases found in the body of certain plants at different stages of maturity and at different times of the day. The amounts of carbon dioxide, oxygen, and nitrogen gases were analyzed. Where these gases came from—whether from the air or as products of certain metabolic processes taking place in the body of the plant, was not actually ascertained by careful experimentation but only by deduction.

## *Review of literature*

In order to have a standard for comparison, the composition of the air is here given. Smith (1918) reports that the ordinary air consists of 20.9 to 21 per cent of oxygen, 78 per cent of nitrogen, and 0.03–0.04 per cent of carbon dioxide, with traces of certain rare gases of the argon group.

It is now fully established that air generally gets into the body of the plant through the stomata and lenticels. Jost (1907) states that the carbon dioxide that has reached the stomatal air chamber cannot travel from cell to cell unless it becomes dissolved in the water of imbibition present in the cell walls.

Several factors of the environment of plants have been found capable of influencing the movements of gases to or from the body of the plant. Temperature is one of these factors. The rate of this exchange of gases in plant body was studied by Wolkoff and Mayer (1874). These authors found that, for medium temperatures, the rate of the gaseous exchange was nearly proportional to the temperature, but a maximum rate was reached at about 40° C.; further rise in temperature was without influence upon this rate, which remained constant until death supervened.

Light, also, has been found to be a factor in the exchange of gases. From the results of his investigation, Kreusler (1885) was able to draw the following generalizations: That the amount of light necessary for the decomposition of carbon dioxide is closely related to the individual properties of the plant. Some plants need more light and others less. In *heliophilous* plants, this author says, the rate of carbon dioxide decomposition increases continuously with increase in light intensity. On the other hand, for *heliophobous* plants there exists an optimum light intensity, and any increase beyond this optimum results in a decrease in the amount of carbon dioxide decomposition.

<sup>1</sup>Thesis presented for graduation, 1925, with the degree of Bachelor of Science in Agriculture, from the College of Agriculture No. 218, Experiment Station contribution No. 341. Prepared in the Department of Plant Physiology; under the direction of Prof. D. A. Herbert during first part of experiment, and under Dr. R. B. Espino, during latter part.

Mathaei (1905) reported that if the illumination is sufficient the carbon dioxide decomposition or the carbohydrate photosynthesis increases directly with the temperature.

Borodin (1876) found that the intensity of respiratory activity in leafy twigs gradually decreased after the twigs were placed in darkness, and rose again after they had been once more illuminated. Mangin (1886) obtained similar results.

The only available literature that directly concerns the subject is the study of Herbert (1923) at this College on "The gas in coconut". This author was able to determine the nature and origin of the gases found in the nuts of the coco-palm. He found that the composition of air in the cavity of the nut varied according to the age of the fruit. In young nuts 2 to 3 cubic centimeters of air was found to contain 81.3 per cent nitrogen, 18.7 per cent oxygen, and a trace of carbon dioxide. On the other hand, in old nuts where the amount of the unknown gas averaged 23 cubic centimeters, 99.8 per cent of it was nitrogen; 0.2 per cent was oxygen and the carbon dioxide was present only in a trace. In interpreting the results he gathered, Herbert states that as the nut increased in age more air entered through the pores. This increase of air accounts for the greater percentage of nitrogen found in the more mature nuts. But, the percentage of oxygen decreased with the age of the nut.

#### *Object of the present work*

The objects of this study were to determine: (a) The oxygen, carbon dioxide, and nitrogen contents of the air found in certain parts of the body of a few tropical plants; (b) To determine the influence of the age of the plant and time of the day upon the relative amounts of these gases.

#### *Time and place of present work*

This study was conducted in the Laboratory of Plant Physiology, in the College of Agriculture, Los Baños, from June, 1924, to February, 1925.

### MATERIALS, METHODS, AND RESULTS

#### *Plants used*

The following plants were tested for the presence of carbon dioxide, oxygen, and nitrogen gases:

*Bamboo and closely allied plants.* Kauayankiling, (*Bambusa vulgaris* Schrad. ex Wendl.; Kauyantunik, (*Bambusa spinosa* Roxb.); Bayog, (*Dendrocalamus merrillianus*, (Ehm.) Elm.); and Boho. (*Schizostachyum lumampao* (Blanco), Merr.), were studied. Stems of each of these plants at different stages of maturity were gathered and the gas contents of each determined. The stem of a plant about six months of age was considered young; about 12 months of age, as *medium*; and fully mature, as *mature*. The ages were only roughly estimated. The gas was obtained from the middle internode of the stem of each plant.

*Rice* (*Oryza sativa* Linn.). Culms of an upland rice, variety Kinandang pula, and culms of a lowland variety Apostol were used. The plants were grown on the College Farm and were about ready for harvest when the tests for the gases were made.

*Abaca* (*Musa textilis* Née.). Only the Maguindanao variety was studied. The outermost leaf sheath from a fruiting stalk and another outermost leaf sheath from a younger plant were gathered. The gases obtained from the midribs of each of the leaf sheaths were analyzed.

*Saba* (*Musa sapientum* var. *compressa* (Blanco) Teodoro). The outermost leaf sheath from a mature fruiting stalk and outermost leaf sheath from a younger stalk were gathered. The gases obtained from the middle of the leaf sheaths were analyzed.

*Water hyacinth* (*Eichornia crassipes* (Mart.) Solms. This plant was collected along the shores of Laguna de Bay near the barrio of Bayog, Los Baños Municipality. The gas was obtained from two petioles of the leaves.

### *Methods of analyses*

The methods employed in the analyses of the gases may be described as follows:

*Collection of gases.* The stems of the bamboo and allied species; the culms or stems of the two varieties of rice; the leaf sheaths of abaca and of saba; and the petioles of the leaves of the water hyacinth were separately gathered and taken to the Laboratory of Plant Physiology. The gases in these organs were collected by displacement. By immersing the stem, the leaf sheath or the petiole in water, the air in the intercellular spaces of these structures was driven off and replaced by water. The bubbles of air thus released were all collected in burettes with a funnel at the open end of each. The air that entered the burettes replaced the water that these receptacles contained.

The air collected was of unknown composition, but it was suspected that it might contain the gases ordinarily found in the atmosphere. Hence it was analyzed for carbon dioxide, oxygen, and for nitrogen.

*Amount of carbon dioxide.* The amount of carbon dioxide collected in the burette was determined by means of the solution of potassium hydroxide. This solution was prepared by dissolving one part of caustic potash in two parts of water (Dennis, 1918). The solution thus prepared was placed in a glass tumbler and into it was dipped the open end of the burette. All the carbon dioxide in the burette was absorbed by this alkali. The alkali rose in the burette and the volume it occupied was equal to volume of carbon dioxide that the burette formerly contained. This was the measure of the volume of the gas and the numerical data obtained are recorded in table 1. The percentages are given in table 2.

*Amount of oxygen.* The air remaining in the burette might still contain other gases; oxygen might be present in it. Oxygen is absorbed by alkaline pyrogallol solution. To test the presence of oxygen, this solution was prepared (Dennis) by dissolving 120 grams of potassium hydroxide not purified by alcohol, in 80 cubic centimeters of water. To this solution was added 5 grams of pyrogallol acid dissolved in 50 cubic centimeters of distilled water. This mixture was poured into the glass tumbler that contained the potassium hydroxide which had been used in the determination of the carbon dioxide content of the air in the burette. The pyrogallol solution gradually rose in the burette, for it absorbed the oxygen and replaced it in the burette. After a few days it stopped rising, —indicating that all the oxygen had been absorbed. The volume occupied by

the pyrogallol solution in the burette was equal to the volume of the oxygen gas which was absorbed by this solution. The data on oxygen are given in table 1 and the percentages in table 2.

*Amount of nitrogen.* The amount of nitrogen gas in the burette or in the plant organs studied was not actually tested. The volume of the air left in the burette after the carbon dioxide and oxygen had been removed was arbitrarily considered to be the volume of nitrogen gas. But, in reality, traces of certain rare gases of the argon group may be found mixed with the nitrogen. The numerical data thus obtained are shown in table 1 and percentages in table 2.

*Time of collection of gases.* Unless otherwise specifically stated (see table 1) the air from the intercellular space was collected in the afternoon from 2:00 to 3:00 o'clock. The collection of the gases made at sunrise are designated in the tables of results as *morning* collection. The collection at 12:00 o'clock noon as *noon* collection; while the air collected from the stem, leaf sheath or petiole at about 9:00 o'clock at night is labelled as *evening* collection.

#### *Computations made*

The percentages of the gases, carbon dioxide, oxygen, and nitrogen, were separately determined. The volume of any of the three gases divided by the volume of the air analyzed and multiplied by 100 gave the percentage of that gas.

The ratio of carbon dioxide to oxygen was obtained by dividing the amount of the first gas by the amount of the second. The data on this are given in tables 1, 2, and 3.

The percentages of a gas ( $\text{CO}_2$ ,  $\text{O}_2$  or N) found from the stems of a plant in different stages of maturity were averaged. The results are given in table 3. Similarly, the percentage of a gas ( $\text{CO}_2$ ,  $\text{O}_2$  or N) obtained from culms, leaf sheaths, or petioles of leaf, in the morning, noon, or in the evening were averaged. The data obtained are shown in table 3.

#### DISCUSSION OF RESULTS

##### *Gases in stems of different ages*

*Carbon dioxide.* Table 2 plainly shows that as the stem advanced in age there was a gradual decrease in the percentage of carbon dioxide found in it. This was found to be true with Kauayan-kiling, Kauayan-tinik, Bayog, and Boho. The stems of Kauayan-tinik, the bamboo which is most used in the Philippines in construction of houses, was found to contain 7.35 per cent carbon dioxide when *young*; when of *medium* age, 4.53 per cent. The *mature* stem, or that which was ready for the market, had 4.37 per cent of carbon dioxide, slightly lower than at medium age. The stem of Boho, which is used in the manufacture of the famous Pampanga sawali, when *young*, had 7.32 per cent of carbon dioxide; when of medium age, 6 per cent; when fully *mature*, only 4.8 per cent.

*Oxygen.* The percentages of this gas in the stems of the bamboos and the closely allied species studied, also varied according to the age of the plant. Data in table 2 support this conclusion. The apparent increase of oxygen in more mature stems is probably due to the fact that its component cells are mostly dead or are no longer actively respiring. Consequently, there is relatively slow removal of the oxygen stored up in the cavity of the stem for respiration. The

*young* stem of Kauayan-tinik had 11.94 per cent of oxygen; when of *medium* age, 13.52 per cent; when fully mature, 13.95 per cent. The young stem of the Boho was found to contain only 12.6 per cent of oxygen; when ready for the market, 13.6 per cent. The Kauayan-tinik and Boho were similar in percentages of oxygen.

*Nitrogen.* This gas was found in rather large quantities in the stems of the three species of plants, Kauayan-kiling, Kauayan-tinik, and Boho. Unlike carbon dioxide and oxygen, the nitrogen gas was found present in the stem in a quantity apparently not influenced by the age of the plant. (See table 2.)

*Ratio of carbon dioxide to oxygen.* In all the species of plants under discussion, the ratio of carbon dioxide to oxygen invariably decreased as the age of the plant or of the stem that contained the gases advanced. The ratios of these two gases in the stems of Kauayan-tinik was 0.616 for *young*, 0.34 for *medium*, and 0.313 for *mature* plants. The ratios of these gases as found in the stem of Boho plants of different ages were 0.581 for the *young* stage; 0.462 for the *medium* stage; and 0.353 for the fully mature plant. (See table 2.)

#### *Variations of gaseous contents as influenced by time of day*

*Carbon dioxide.* The percentage of carbon dioxide in the culms of the two varieties of rice; in the petioles of water hyacinth; in the leaf sheaths of abaca and banana was greater at noon than in the morning or in the evening. This statement is supported by the data in table 2. Some of the data in this table show further that, with the exception of the water hyacinth, the percentage of carbon dioxide collected in the morning was greater than that collected in the evening. If this gas is a product of respiration of the stem, the highest record being obtained at noon is in full accord with the findings of Wolkoff and Mayer (1874). Temperature of the air is apparently the controlling, or the limiting factor in the production of carbon dioxide in the stem. The width of the stomatal pore is another factor that may influence the rate of accumulation of the gas in the stem. The wide open stomatal pores usually observed at noon allow, of course, exchange of gases faster than is possible when the stomatal pores are partly closed. This is really the case if the gases that enter the leaves travel to the stem. It is well known that most of the carbon dioxide is used up in carbohydrate photosynthesis, and some is temporarily stored in the intercellular spaces of the leaf. Stomata are present on the stem, culm, petiole, and leaf sheath studied. The stomata on these organs behave in a manner similar to that of the stomata on the leaves. The movement of the stomatal pores is also influenced by certain environmental factors, the principal one being the temperature of the air. As at noon, when the stomata are generally wide open, the entrance of carbon dioxide into the stem, leaf sheath or petiole is quite rapid; hence the greater amount of this gas at noon in the organs studied. Respiration, which is generally more active at noon, and the rapid entrance of the gas in the stem at the same hour are both responsible, probably, for the greater percentage of carbon dioxide found at that time.

*Oxygen.* The percentages of oxygen found in the stems of the two varieties of rice, in the petiole of the leaf of water hyacinth, in the leaf sheath of an abaca (except when fruiting), and leaf sheath of Saba, were smaller at noon than in the morning or in the evening (see table 2). In accordance with results of the re-

searches of Kreusler (1885), the relatively less oxygen gas at noon was due to a more rapid respiration taking place in the stem at that hour. This rapidity, in turn, is probably due to the temperature of the air at noon being higher than it is either in the morning or in the evening. This result seems to suggest that, more than any other factor, respiration was responsible for the greater part of the accumulation of carbon dioxide gas in the organs of the plants under consideration.

*Nitrogen.* Table 2 shows that the amounts of nitrogen in the organs of the plants studied were not influenced by the time of the day. This was probably due to the fact that nitrogen in elemental form is not used by higher plants, especially when found in the organs here studied. The apparent slight and irregular fluctuations shown in table 2 are possibly due to the relative exhaustion of the other gases.

*Ration of carbon dioxide to oxygen.* As shown in table 2, the ratio of these two gases was invariably greater at noon than in the evening or at night. It was also found that the ratio in the morning was greater than at night. Taking two concrete examples from the table, the lowland rice, variety Apostol, and abaca; the ratios of the carbon dioxide to oxygen in the culms of the rice were 0.319 in the morning, 0.461 at noon, and 0.179 at night; in the abaca, from the leaf sheath of variety Maguindanao not fruiting, 0.196 for the morning collection; 0.254 at noon, and 0.131 in the evening.

#### *Gases content in body of closely related plants*

*Bamboo and allied species.* In terms of average amounts of gases, the two species of bamboo and the other closely allied species will be compared. The data in table 3 show that the contents of carbon dioxide and of oxygen in the stem of Kauayan-kiling were strikingly different from the contents of the same gases in the stems of the other species. Kauayan-kiling had 3.74 per cent of carbon dioxide, which is noticeably low; and 16.17 per cent of oxygen, which is high. Kauayan-tinik, Bayog, and the Boho had in their stems about the same contents of these two gases. Kauayan-tinik had 5.42 per cent carbon dioxide and 13.07 per cent oxygen; Bayog, 5.92 per cent carbon dioxide and 13.07 per cent oxygen; Boho had 6.04 per cent of carbon dioxide, the highest amount, and 13.07 per cent of oxygen. The close similarity in gas contents of the stems of the last three kinds of plants might indicate similarity in rate of respiration of their stems. The four species had about the same percentages of nitrogen gas.

*An upland rice and a lowland rice.* It may be seen in table 3 that the gas contents in the culms of the two varieties of rice were quite similar. However, the lowland variety had 4.93 per cent carbon dioxide and the upland variety, 4.03 per cent. The lowland rice had also a greater content of oxygen, 15.08 per cent; while the upland had only 12.1 per cent. In the culm of the upland variety a greater amount of nitrogen gas, 83.88 per cent, was found than in the lowland, which had 90.07 per cent.

*Abaca and banana compared.* The data in the lower part of table 3 show the close similarity of the results obtained with the abaca and with the banana, with respect to the contents of carbon dioxide, oxygen, and nitrogen. The abaca variety Maguindanao had in its outer-most leaf sheath 3.12 per cent car-

bon dioxide; 16.73 per cent oxygen; and 80.15 per cent nitrogen. The Saba had 3.00 per cent carbon dioxide; 17.65 per cent oxygen; and 79.34 nitrogen.

*The water hyacinth.* In the petioles of the water hyacinth were found 2.41 per cent carbon dioxide; 17.67 per cent oxygen; and 79.34 per cent nitrogen.

*Composition of ordinary air and of the air found in the organs studied*

The difference between the compositions (see tables 2 and 3) of the air found in the organs of the plants studied and the composition of the ordinary air as reported by Smith (1918) is strikingly great. Greater percentages of carbon dioxide and of nitrogen were obtained from the plants than were found in the air.

The air in the atmosphere, however, contains about 21 per cent of oxygen gas; while in plant organs studied, this gas was found as low as 12.1 per cent. How may these differences be explained?

Indications are strong that the accumulation or the presence of these gases in the plant parts studied was principally the result of respiration either going on or taking place in them. If this is true, then this process accounts for the accumulation of carbon dioxide and the diminution of oxygen; for the process of respiration consumes oxygen and gives off carbon dioxide.

Is respiration the only source of these gases? The answer must be in the negative, because large amounts of nitrogen gas were found in the stems, leaf sheaths, and in the petioles. This gas is not a product of, nor does it have any part in the respiration of those organs. So the nitrogen could not have been there unless it had passed through the stomata on the stem, leaf sheath or petiole of these plants, or have entered the body of the plant through other passages and traveled from cell to cell in liquid form until it became again a gas in the air cavities in the plant bodies.

SUMMARY

1. As the stem of bamboo advanced in age there was a gradual decrease in the percentage of carbon dioxide and a progressive increase in the percentage of oxygen. The nitrogen gas was apparently not influenced by the age of the plant.

2. The ratio of carbon dioxide to oxygen was invariably decreased as the age of the plant or of the stem that contained the gases advanced.

3. The percentages of carbon dioxide were greater at noon than either in the morning or evening. While the percentages of oxygen found in the stems of the two varieties of rice, in the petiole of the leaf of water hyacinth, in the leaf sheath of an abaca (except when fruiting), and leaf sheath of Saba were smaller at noon than the percentages of this gas in this organ in the morning or evening.

4. The average amounts of carbon dioxide, oxygen, and nitrogen in the body of closely related plants were decidedly different.

5. The percentages of carbon dioxide and nitrogen gases obtained from the plants were greater than the percentages of these gases as found in the air, but the percentages of oxygen were the reverse.

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TABLE 1

Amount of gases obtained from the stems, leaf sheaths, and petioles of plants of different stages of maturity<sup>a</sup>

| SPECIES                                                                     | AGE OR TIME OF OBSERV. | VOL. OF GAS ANALYZED | AMOUNT OF CARBON DIOXIDE GAS |          | AMOUNT OF OXYGEN GAS |          | AMOUNT OF NITROGEN GAS |          | RATIO OF CO <sub>2</sub> O <sub>2</sub> |
|-----------------------------------------------------------------------------|------------------------|----------------------|------------------------------|----------|----------------------|----------|------------------------|----------|-----------------------------------------|
|                                                                             |                        |                      | cc.                          | per cent | cc.                  | per cent | cc.                    | per cent |                                         |
| Kaauayan-kiling,<br>Bambusa vulgaris Schrad ex Wendl.                       | Young                  | 172.00               | 17.00                        | 4.06     | 27.00                | 15.70    | 138.00                 | 80.24    | 0.259                                   |
|                                                                             | Medium                 | 500.00               | 18.00                        | 3.60     | 82.00                | 16.40    | 400.00                 | 80.00    | 0.220                                   |
|                                                                             | Mature                 | 505.00               | 18.00                        | 3.56     | 83.00                | 16.44    | 404.00                 | 80.19    | 0.217                                   |
| Kaauayan-tinik,<br>Bambusa spinosa Roxb.                                    | Young                  | 54.4                 | 4.00                         | 7.35     | 6.50                 | 11.94    | 198.35                 | 79.98    | 0.497                                   |
|                                                                             | Medium                 | 54.05                | 2.45                         | 4.53     | 7.40                 | 13.32    | 200.50                 | 80.20    | 0.414                                   |
|                                                                             | Mature                 | 53.75                | 2.35                         | 4.37     | 7.50                 | 13.95    | 197.50                 | 80.60    | 0.376                                   |
| Bayog,<br>Dendrocalamus merrillianus (Elm.) Elm.                            | Young                  | 248.00               | 16.50                        | 6.65     | 33.15                | 13.37    | 43.90                  | 80.71    | 0.616                                   |
|                                                                             | Medium                 | 250.00               | 14.50                        | 5.80     | 35.00                | 14.00    | 44.20                  | 82.15    | 0.340                                   |
|                                                                             | Mature                 | 245.00               | 13.00                        | 5.30     | 34.50                | 14.08    | 42.90                  | 81.68    | 0.313                                   |
| Boho,<br>Schizostachyum lumampao (Blanco), Merr.                            | Young                  | 246.00               | 18.00                        | 7.32     | 31.00                | 12.60    | 197.00                 | 80.08    | 0.581                                   |
|                                                                             | Medium                 | 250.00               | 15.00                        | 6.00     | 33.00                | 13.00    | 202.90                 | 81.00    | 0.462                                   |
|                                                                             | Mature                 | 250.00               | 12.00                        | 4.80     | 34.00                | 13.60    | 204.00                 | 81.60    | 0.353                                   |
| Lowland rice,<br>Oryza sativa Linn. Var. Apostol                            | Morning                | 53.70                | 2.50                         | 4.66     | 7.85                 | 14.62    | 43.35                  | 80.82    | 0.319                                   |
|                                                                             | Noon                   | 52.30                | 3.70                         | 7.07     | 7.10                 | 13.58    | 41.50                  | 79.50    | 0.461                                   |
|                                                                             | Evening                | 52.20                | 1.60                         | 3.06     | 8.90                 | 17.05    | 41.70                  | 79.89    | 0.179                                   |
| Upland rice,<br>Oryza sativa Linn. Var. Kinandang-pula                      | Morning                | 52.60                | 2.05                         | 3.80     | 7.20                 | 13.69    | 43.40                  | 82.51    | 0.278                                   |
|                                                                             | Noon                   | 52.50                | 2.70                         | 5.14     | 6.20                 | 11.81    | 43.60                  | 83.05    | 0.435                                   |
|                                                                             | Evening                | 53.70                | 1.70                         | 3.17     | 5.80                 | 10.80    | 46.50                  | 86.03    | 0.294                                   |
| Water-hyacinth,<br>Eichornia crassipes (Mart) Solms.                        | Morning                | 53.10                | 1.15                         | 2.16     | 9.75                 | 18.36    | 42.20                  | 79.48    | 0.118                                   |
|                                                                             | Noon                   | 52.50                | 1.37                         | 2.60     | 8.95                 | 17.10    | 42.18                  | 80.30    | 0.152                                   |
|                                                                             | Evening                | 52.70                | 1.30                         | 2.46     | 9.25                 | 17.55    | 42.15                  | 79.99    | 0.140                                   |
| Abaca,<br>Musa textilis Née, Var. Maguindanao<br>(with fruits)              | Morning                | 54.00                | 1.80                         | 3.33     | 7.70                 | 14.26    | 44.50                  | 82.41    | 0.234                                   |
|                                                                             | Noon                   | 53.50                | 2.20                         | 4.11     | 9.20                 | 16.85    | 42.10                  | 79.01    | 0.244                                   |
|                                                                             | Evening                | 52.60                | 0.80                         | 1.52     | 9.80                 | 18.63    | 42.00                  | 79.85    | 0.082                                   |
| Abaca,<br>Musa textilis Née, Var. Maguindanao<br>(without fruits)           | Morning                | 52.90                | 1.75                         | 3.31     | 8.95                 | 16.92    | 42.20                  | 79.77    | 0.196                                   |
|                                                                             | Noon                   | 53.20                | 2.20                         | 4.13     | 8.65                 | 16.25    | 42.35                  | 79.62    | 0.254                                   |
|                                                                             | Evening                | 52.20                | 1.20                         | 2.29     | 9.10                 | 17.43    | 41.90                  | 80.28    | 0.131                                   |
| Saba,<br>Musa sapientum compressa var. (Blanco)<br>Teodoro (with fruits)    | Morning                | 54.25                | 1.50                         | 2.77     | 10.50                | 19.35    | 42.25                  | 77.82    | 0.143                                   |
|                                                                             | Noon                   | 55.60                | 2.60                         | 4.67     | 9.92                 | 16.05    | 42.08                  | 79.28    | 0.291                                   |
|                                                                             | Evening                | 52.70                | 0.75                         | 1.42     | 10.25                | 19.45    | 41.70                  | 79.13    | 0.073                                   |
| Saba,<br>Musa sapientum var. compressa (Blanco)<br>Teodoro (without fruits) | Morning                | 57.20                | 1.55                         | 2.70     | 9.25                 | 16.17    | 46.40                  | 81.13    | 0.166                                   |
|                                                                             | Noon                   | 56.60                | 2.80                         | 4.95     | 10.52                | 15.94    | 43.28                  | 79.11    | 0.311                                   |
|                                                                             | Evening                | 52.80                | 0.80                         | 1.52     | 10.00                | 18.94    | 42.00                  | 79.54    | 0.080                                   |

<sup>a</sup> The scientific names were verified by Dr. E. Quisumbing of the Department of Plant Physiology.



TABLE 2

*Amounts of carbon dioxide, oxygen, and nitrogen gases found in plants of different ages and at different times of the day*

*(Data compiled from table 1)*

| NAME OF PLANTS                                 | AGE OR TIME OF OBSERV. | CARBON DIOXIDE  | OXYGEN          | NITROGEN        | RATIO OF CO <sub>2</sub> O <sub>2</sub> |
|------------------------------------------------|------------------------|-----------------|-----------------|-----------------|-----------------------------------------|
|                                                |                        | <i>per cent</i> | <i>per cent</i> | <i>per cent</i> |                                         |
| Kauayan-kiling.....                            | Young.....             | 4.06            | 15.70           | 80.24           | 0.259                                   |
|                                                | Medium.....            | 3.60            | 16.40           | 80.00           | 0.220                                   |
|                                                | Mature.....            | 3.55            | 16.44           | 80.19           | 0.217                                   |
| Kauayan-tinik.....                             | Young.....             | 7.35            | 11.94           | 80.70           | 0.616                                   |
|                                                | Medium.....            | 4.53            | 13.32           | 82.15           | 0.340                                   |
|                                                | Mature.....            | 4.37            | 13.95           | 81.68           | 0.313                                   |
| Bayog.....                                     | Young.....             | 6.65            | 13.37           | 79.98           | 0.497                                   |
|                                                | Medium.....            | 5.80            | 14.00           | 80.20           | 0.414                                   |
|                                                | Mature.....            | 5.30            | 14.08           | 80.60           | 0.376                                   |
| Boho.....                                      | Young.....             | 7.32            | 12.60           | 80.08           | 0.581                                   |
|                                                | Medium.....            | 6.00            | 13.00           | 81.00           | 0.462                                   |
|                                                | Mature.....            | 4.80            | 13.60           | 81.60           | 0.353                                   |
| Lowland rice, Var. Apostol.....                | Morning.....           | 4.66            | 14.62           | 80.82           | 0.319                                   |
|                                                | Noon.....              | 7.07            | 13.58           | 79.50           | 0.461                                   |
|                                                | Evening.....           | 3.06            | 17.05           | 79.89           | 0.179                                   |
| Upland rice,.....<br>Var. Kinandang-pula       | Morning.....           | 3.80            | 13.69           | 82.51           | 0.278                                   |
|                                                | Noon.....              | 5.14            | 11.81           | 83.05           | 0.435                                   |
|                                                | Evening.....           | 3.17            | 10.80           | 86.03           | 0.294                                   |
| Water hyacinth.....                            | Morning.....           | 2.16            | 18.36           | 79.48           | 0.118                                   |
|                                                | Noon.....              | 2.60            | 17.10           | 80.30           | 0.152                                   |
|                                                | Evening.....           | 2.46            | 17.55           | 79.99           | 0.140                                   |
| Abaca, Var. Maguindanao.....<br>(fruiting)     | Morning.....           | 3.33            | 14.26           | 82.41           | 0.234                                   |
|                                                | Noon.....              | 4.11            | 16.85           | 79.04           | 0.244                                   |
|                                                | Evening.....           | 1.52            | 18.63           | 79.85           | 0.082                                   |
| Abaca, Var. Maguindanao.....<br>(not fruiting) | Morning.....           | 3.31            | 16.92           | 79.77           | 0.196                                   |
|                                                | Noon.....              | 4.13            | 16.25           | 79.62           | 0.254                                   |
|                                                | Evening.....           | 2.29            | 17.43           | 80.26           | 0.131                                   |
| Saba.....<br>(fruiting)                        | Morning.....           | 2.77            | 19.35           | 77.88           | 0.143                                   |
|                                                | Noon.....              | 4.67            | 16.05           | 79.28           | 0.291                                   |
|                                                | Evening.....           | 1.42            | 19.45           | 79.13           | 0.073                                   |
| Saba.....<br>(not fruiting)                    | Morning.....           | 2.70            | 16.17           | 81.13           | 0.166                                   |
|                                                | Noon.....              | 4.95            | 15.94           | 79.11           | 0.311                                   |
|                                                | Evening.....           | 1.52            | 18.94           | 79.54           | 0.080                                   |

TABLE 3

*Average amounts of gases found in nine kinds of plants*

*(Data compiled from table 2)*

| NAME OF PLANT                    | PART OF PLANT BODY WHERE THE GASES WERE FOUND | CARBON DIOXIDE  | OXYGEN          | NITROGEN        |
|----------------------------------|-----------------------------------------------|-----------------|-----------------|-----------------|
|                                  |                                               | <i>per cent</i> | <i>per cent</i> | <i>per cent</i> |
| Kauayan-kiling.....              | Stem.....                                     | 3.74            | 16.17           | 80.14           |
| Kauayan-tinik.....               | Stem.....                                     | 5.42            | 13.07           | 81.51           |
| Bayog.....                       | Stem.....                                     | 5.92            | 13.82           | 80.26           |
| Boho.....                        | Stem.....                                     | 6.04            | 13.07           | 80.69           |
| Lowland rice, Var. Apostol.....  | Culm.....                                     | 4.93            | 15.08           | 80.07           |
| Upland rice, Var. Kinandang-pula | Culm.....                                     | 4.03            | 12.10           | 83.88           |
| Water hyacinth.....              | Petiole.....                                  | 2.41            | 17.67           | 79.92           |
| Abaca, Var. Maguindanao.....     | Leaf sheath...                                | 3.12            | 16.73           | 80.16           |
| Saba.....                        | Leaf sheath...                                | 3.00            | 17.65           | 79.34           |



# TANNIN PLANTS OF MAQUILING REGION<sup>1</sup>

AURELIANO J. VILLANUEVA

## INTRODUCTION

The tannin barks constitute the greatest single source of tanning material in the Philippines. The species of trees which can be used for tanning purposes grow in the Philippines in large numbers; there are extensive supplies of tan bark in the swamps and forests in the Archipelago (Brown et al., 1918). In this product, the Philippines possesses an advantage over such countries as Borneo, in that owing to the country's large population the wood, after the bark has been taken off, can be used as firewood; so it would seem advisable to combine the tan bark collection with the cutting of firewood. As the tanning industry in the Islands has never been developed, these tan barks are used only locally, and to a limited extent.

The investigation here reported was carried out to an extent that covered a number of the possible sources of tanning materials. The work was done in the hope that if many species of tannin plants should be found, small local tanneries may have a large number of species on which to draw for their supplies.

The investigation is an important one, not only from the point of view of the domestic consumption by tanneries, but also from that of the exportation of tanning materials to foreign countries. Any promising new product, if well developed, helps the commerce of the Islands.

## *Review of Literature*

*Chemistry of tannins.* Ganong (1920) states that the tannins occur chiefly in the bark of plants, where their bitter astringent taste has been supposed to protect the trees against rodents and insects, while a certain antiseptic quality prevents the development of parasitic fungi and hence the decay of the bark. He points out, also, that it is the oxidation changes in these tannins under weathering which give the dark brown color to old bark. He says further that, having incidentally the remarkable property of hardening the gelatin in skins, they are utilized by man for tanning leather, though the chemist is now providing artificial substitutes for tannins.

<sup>1</sup> Thesis prepared, in part, for presentation for graduation for the degree of Bachelor of Agriculture from the College of Agriculture, No. 219; Experiment Station contribution No. 342. Work was done in the Department of Plant Physiology under the direction of Prof. D. A. Herbert.

On November 28, 1925, Mr. Villanueva died in the Philippine General Hospital, Manila. He had prepared this thesis, in part, to present for graduation in March, 1926. His collegiate work was of such quality that he would have been graduated with the class of '26, had not the sickle of the "Reaper whose name is Death" cut him down ere the flower for the future grain had budded.

His cheerful disposition and happy smile made Mr. Villanueva popular with his college mates; for his sterling qualities he was esteemed. Through his untimely death, agriculture, especially the science of botany, lost an earnest and promising worker. This paper is published at this time as an inadequate, but a permanent memorial to its author, Aureliano J. Villanueva.—R. B. E.

Duggar (1911) states that tannins are bitter, astringent, water soluble, amorphous substances, widely distributed in the barks, leaves, and fruits of plants. All of these substances are of commercial importance, as they may be employed in the process of tanning skins and hides since they form insoluble compounds with various nitrogenous bodies, giving a toughness and durability to the skin which constitutes the differences between leather and natural skin.

This authority points out that tannins are alike in certain physical and chemical properties, but they may be dissimilar in chemical composition. The tannin used in the making of leather is usually derived from the bark of various trees. Duggar says also that tannin is extensively used as a mordant in the process of dyeing, for it produces colored products with various dye stuffs; and it has long been employed in the manufacture of ink. Upon heating with sulfuric acid, tannic acid is hydrolyzed, yielding two molecules of gallic acid. This process is also accomplished naturally by means of the action of a few fungi, especially, *Aspergillus niger*.

Ingle (1908) states that tannic acid or tannin is very abundantly distributed in the vegetable kingdom. It varies in composition and properties according to its origin. This writer points out that tannin was formerly looked upon as a glucoside but the tannic acid, its chief constituent, is now looked upon as an anhydro-acid. Gallo-tannic acid, for example, is said to have the constitution  $C_6H_2(OH)_2 \cdot CO \cdot O \cdot C_6H_2(OH)_2 \cdot COOH$ . It is hydrolyzed by dilute acid or by ferments, with the production of gallic acid ( $C_6H_2(OH)_3 \cdot COOH$ ). This authority further says that natural tannins are usually associated or combined with glucosides, and on hydrolysis yield glucose in addition to gallic acid. Also, the tannins possess a strongly astringent taste, give intense blue or green-black colors with ferric chloride solution and possess the power of converting gelatin into an insoluble substance. They tend to absorb oxygen, especially in the presence of alkalies, giving a dark brown coloration.

In the *Philippine Journal of Science*, Gana (1915) reports that the bark of camanchile, *Pithecolobium dulce* (Roxb.) Benth, is brownish gray and rough outside and reddish brown inside. It produces dull but light-colored leather which reddens on exposure to light. An infusion of it contains a tannin of the catechol class which gives a green-black precipitate with iron salts, a light brown precipitate with bromine water, and crimson line when in contact with one drop of concentrated sulfuric acid. An analysis given of a representative sample of the bark of camanchile gave the following results, calculated on water-free material: Total extract 34.77 per cent; non-tannin 9.41 per cent; tannin 25.36 per cent.

Gana states, also, that camanchile bark infusion soon ferments and decomposes in the climate of the Philippines, resulting in the destruction of tannins, the development of a disagreeable odor and a thickening of the liquid due to a viscous gelatinous formation which accumulates and grows on the surface. A few experiments with phenol as a preservative showed that a concentration of 0.01 per cent does not check the fermentation appreciably, as in a control infusion the tannins were destroyed, the color became a deep wine red at least three times as intense as the original red orange; a somewhat penetrating smell was given off, and a gelatinous formation and a slimy sediment developed, which made the infusion viscous. Camanchile bark contains irritating principles, which are believed

by laborers in the tanneries to indicate roughly the strength of infusion. Infection of the eyes, producing weakening of the sight and irritation and swelling of the eyelids are attributed to these principles.

*Commercial literature.* Brown and Fischer (1918) report that the mangrove barks constitute the greatest single source of tanning materials in the Islands. These writers point out that by the investigations made by Bacon and Gana and by Williams in Mindanao and Mindoro (Gana, 1915) the species *Rhizophora candelaria*, *Rhizophora mucronata*, *Bruguiera conjugata*, *Bruguiera sexangula*, *Ceriops tagal*, and *Ceriops roxburghiana* constitute the mangrove trees which furnish the greatest amount of tanning materials. They say that various results have been obtained by analyzing the barks of the same species, and that it has been stated often that the bark from some countries is richer in tannin than that from others. The same authorities say that barks, in drying, lose a certain portion of their tannin, especially if they are not properly dried. According to Williams, the percentage of tannin increases with the size of the tree, but the increase is due rather to the age than to the size. Brown and Fischer report that the Philippine barks appear to be as rich in tannin as those in Borneo which are used in the cutch factories. They say, also, that there are areas in Mindanao, Mindoro, and Palawan which, although they may not be as large as some in Borneo, still offer promising sites for cutch factories. That in Sibuguey Bay, Mindanao, there is a well developed swamp covering an area of 25,000 hectares which will yield about 20 metric tons to the hectare of fresh bark of mature trees, selected species, averaging about 28 to 30 per cent of tannin on the dry weight. This area offers only four species: *Rhizophora mucronata*, *Rhizophora conjugata*, *Rhizophora gymnorhiza* and *Bruguiera eriopetala*. The first two are known as Bacauan (Tag.), and the two last as Pototan (Tag.). In Mindoro, there is a tract of 10,000 hectares and in Palawan, a fairly compact area of good swamp.

According to Gana (1915), the only tanning materials used in the Philippines are the various species of mangrove (*Rhizophoraceae*, or mangrove family) and the camanchile tree (*Pithecolobium dulce* (Roxb.) Benth). The former, being plentiful, is cheap, selling for about 25 pesos a metric ton. In spite of the cheapness and their high tanning content, mangrove barks are not used extensively in the Philippines outside of the city of Manila. Camanchile bark is used almost exclusively by Filipino tanners, who prefer it on account of the high-colored leather it produces. Because of the demand, the price of the air-dried camanchile bark is as high as 10 pesos for 100 kilograms.

Cutch, a product of the heartwood of *Acasia catechu* Willd, has been known in India and Burma for many years (Foxworthy, 1908). It is used both as a dye and for tanning. Considerable quantities are exported to Europe for use in dyeing cotton goods. The supply is not entirely uniform or reliable because of the scattered manner in which the trees grow.

Several of the different varieties of mangrove trees in India and Burma were found to have barks which furnished excellent dye and tanning materials. Those varieties then began to be considered as a possible source of cutch to take the place of the Indian article.

It was found to be a comparatively simple matter to prepare the mangrove bark extract and the supply of mangroves was very great, so several companies started preparing the extract in the extensive swamps of Borneo. The product

succeeded in the market and superseded the Indian cutch to such an extent that the term is now used in commerce mainly with reference to mangrove extract.

### *Objects of present work*

It was the aim to this work, (a) To find the possible species of plants which contain tanning materials; (b) To determine the organs of the plants which contain the most and the least amounts of tannin.

### *Time and place of present work*

The investigation was begun June, 1924, and closed September, 1924. It was made principally in the Maquiling Region, Los Baños, Laguna, P. I. The plants on the College Campus and its surroundings were tested. Many plants on Copeland Hill and around the Forest School were tested. Also many plants near the trail from the Forest School to the summit of Maquiling. The plants here reported are those which grow in easily accessible places and hence have good commercial value. Many of the members of the parang trees were examined also.

### MATERIALS AND METHODS

In testing for the presence of tannin, the reagent used was a 5 per cent solution of ferric chloride ( $\text{FeCl}_3$ ). The apparatus used included a graduated cylinder, a bolo, a bottle (for the 5 per cent prepared solution), and a fountain pen ink-filler.

The test was made by chopping the bark of a plant with a sharp bolo or knife, then applying several drops of the 5 per cent prepared solution of  $\text{FeCl}_3$  to the chopped portion. A blue or green-black color indicates the presence of tannin. Some of the leaves of every plant tested were cut crosswise and the same reagent applied; if a corresponding blue or green-black reaction appeared, the part tested contained tannin. The bark of the roots, as well as the flowers and fruits available, were examined in the same way.

### RESULTS

The results in full of this investigation are presented in tabulated form under "Table of Results". The tabulation gives both the common and the scientific names of the plants grouped in families. The habitat of each plant tested is given. In the table of results, these symbols are used:

- + = positive, or the presence of tannin
- = negative, or the absence of tannin
- 1 = slightly positive, or present only in traces
- Q = fruits not available
- C. G. = College Grounds
- b = between Forest School and First Camp
- H = Doctor Hamilton's place
- For. = Forest School

From the results of this investigation, it appears that,—

(1) Of the thirty plant families studied, the Anacardiaceæ, Burseraceæ, Combretaceæ, Datisceæ, Delleniaceæ, Dipterocarpaceæ, Ebenaceæ, Euphor-

biaceæ, Leguminosæ, Melastomaceæ, Myrtaceæ, Sapotaceæ, Verbenaceæ, and Vitaceæ (fourteen families) have members that contain tannin in more or less appreciable quantity.

(2) Tannin was found present in the bark of stem, in the leaf and roots of some of the plants studied.

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TABLE OF RESULTS

| FAMILY NAME, SCIENTIFIC, AND COMMON NAMES <sup>a</sup> | HABITAT | BARK OF<br>STEM | LEAF | ROOTS | FRUITS |
|--------------------------------------------------------|---------|-----------------|------|-------|--------|
| <b>ANACARDIACEÆ</b>                                    |         |                 |      |       |        |
| <i>Anacardium occidentale</i> (kasoi; cashew).....     | C. G.   | +               | +    | +     | Q      |
| <i>Buchanania arborescens</i> (balinhasay).....        | b       | +               | +    | +     | Q      |
| <i>Dracontemelum</i> (dao dao).....                    | For.    | +               | +    | +     | Q      |
| <i>Koordersiodendron pinnatum</i> (amugis).....        | b       | +               | +    | +     | Q      |
| <i>Mangifera indica</i> (mango).....                   | C. G.   | +               | +    | +     | Q      |
| <i>Mangifera caesia</i> .....                          | C. G.   | +               | +    | +     | Q      |
| <i>Rhus rufa</i> .....                                 | C. G.   | +               | +    | +     | Q      |
| <i>Spondias purpurea</i> (ciruela).....                | C. G.   | +               | +    | +     | Q      |
| <b>ANONACEÆ</b>                                        |         |                 |      |       |        |
| <i>Anona muricata</i> (guayabano).....                 | C. G.   | +               | +    | +     | Q      |
| <i>Anona reticulata</i> (anonas).....                  | C. G.   | +               | +    | +     | Q      |
| <i>Anona squamosa</i> (ates).....                      | C. G.   | +               | +    | +     | Q      |
| <i>Canangium odoratum</i> (ilang-ilang).....           | C. G.   | +               | +    | +     | Q      |
| <b>BIGNONIACEÆ</b>                                     |         |                 |      |       |        |
| <i>Spathodea campanulata</i> .....                     | C. G.   | —               | —    | —     | Q      |
| <b>BURSERACEÆ</b>                                      |         |                 |      |       |        |
| <i>Canarium multipinnatum</i> (dulit).....             | b       | +               | +    | +     | Q      |
| <i>Canarium villosum</i> (pagsaingan).....             | C. G.   | +               | +    | +     | Q      |
| <i>Garuga abilo</i> (bogo).....                        | b       | +               | +    | +     | Q      |
| <b>COMBRETACEÆ</b>                                     |         |                 |      |       |        |
| <i>Terminalia comintana</i> (banigias).....            | C. G.   | +               | +    | +     | Q      |
| <i>Terminalia edulis</i> (kalumpit).....               | b       | +               | +    | +     | Q      |
| <i>Terminalia nitens</i> (sakat).....                  | b       | +               | +    | +     | Q      |
| <b>DATISCEACEÆ</b>                                     |         |                 |      |       |        |
| <i>Octomeles sumatrana</i> (binuang).....              | b       | +               | +    | +     | Q      |
| <b>DILLENIACEÆ</b>                                     |         |                 |      |       |        |
| <i>Dillenia philippinensis</i> (katmon).....           | b       | +               | +    | +     | Q      |
| <b>DIPTEROCARPACEÆ</b>                                 |         |                 |      |       |        |
| <i>Parashorea malaanonan</i> (bagtican lauan)....      | C. G.   | +               | +    | +     | Q      |
| <i>Pentacme contorta</i> (lauan-pula).....             | b       | +               | +    | +     | Q      |
| <i>Shorea guiso</i> (guiho).....                       | b       | +               | +    | +     | Q      |
| <b>EBENACEÆ</b>                                        |         |                 |      |       |        |
| <i>Diospyros discolor</i> (mabolo).....                | C. G.   | +               | +    | +     | Q      |
| <b>EUPHORBIACEÆ</b>                                    |         |                 |      |       |        |
| <i>Aleurites moluccana</i> (lumbang).....              | C. G.   | +               | —    | +     | Q      |
| <i>Antidesma bunius</i> (bignai).....                  | C. G.   | +               | —    | +     | Q      |
| <i>Cleidion spiciflorum</i> (santike).....             | b       | +               | +    | +     | Q      |
| <i>Codiaeum variegatum</i> (San Francisco).....        | C. G.   | —               | —    | —     | Q      |
| <i>Hura crepitans</i> (sand box tree).....             | C. G.   | +               | +    | +     | Q      |
| <i>Jatropha curcas</i> (tuba).....                     | C. G.   | +               | +    | +     | Q      |
| <i>Macaranga tanarius</i> (samac).....                 | H       | +               | +    | +     | Q      |
| <i>Mallotus philippensis</i> (banato).....             | b       | +               | +    | +     | Q      |
| <i>Mallotus ricinoides</i> (hinlaumo).....             | b       | +               | +    | +     | Q      |
| <i>Neotrewia cumingii</i> (bato-bato).....             | b       | +               | +    | +     | Q      |
| <i>Sapium luzonicum</i> (balakat-gubat).....           | b       | +               | +    | +     | Q      |
| <b>LAURACEÆ</b>                                        |         |                 |      |       |        |
| <i>Persea americana</i> (avocado).....                 | C. G.   | +               | +    | +     | Q      |
| <b>LECYTHIDACEÆ</b>                                    |         |                 |      |       |        |
| <i>Planchonia spectabilis</i> (lamog).....             | b       | +               | +    | +     | Q      |

<sup>a</sup>The names have been checked by Dr. E. Quisumbing of the Plant Physiology Department.



TABLE OF RESULTS—(Continued)

| FAMILY NAME, SCIENTIFIC, AND COMMON NAMES         | HABITAT | BARK OF<br>STEM | LEAF | ROOTS | FRUITS   |
|---------------------------------------------------|---------|-----------------|------|-------|----------|
| <b>LEGUMINOSÆ</b>                                 |         |                 |      |       |          |
| <i>Acacia koa</i> (koa tree).....                 | C. G.   | +               | +    | +     | ●●●●●●●● |
| <i>Albizzia chinensis</i> (unik).....             | b       | +               | +    | +     | ●●●●●●●● |
| <i>Bauhinia purpurea</i> (alibangbang).....       | C. G.   | —               | —    | —     | ●●●●●●●● |
| <i>Cassia siamea</i> (acacia).....                | C. G.   | +               | +    | +     | ●●●●●●●● |
| <i>Samanea saman</i> (rain tree).....             | C. G.   | —               | —    | —     | ●●●●●●●● |
| <i>Erythrina variegata</i> (dapdap).....          | C. G.   | +               | +    | +     | ●●●●●●●● |
| <i>Gilircidia sepium</i> (madre cacao).....       | C. G.   | —               | —    | —     | ●●●●●●●● |
| <i>Hæmatoxylon campechianum</i> (logwood).....    | For.    | +               | +    | +     | ●●●●●●●● |
| <i>Pahudia rhomboidea</i> (tindalo).....          | For.    | —               | —    | —     | ●●●●●●●● |
| <i>Parkia javanica</i> (cupang).....              | b       | +               | +    | +     | ●●●●●●●● |
| <i>Peltophorum inerme</i> .....                   | C. G.   | +               | +    | +     | ●●●●●●●● |
| <i>Pithecolobium dulce</i> (kamanchile).....      | C. G.   | +               | +    | +     | ●●●●●●●● |
| <i>Pithecolobium scutiferum</i> (karignis).....   | b       | +               | +    | +     | ●●●●●●●● |
| <b>LILIACEÆ</b>                                   |         |                 |      |       |          |
| <i>Taetsia fruticosa</i> (sagilala).....          | C. G.   | —               | —    | —     | ●        |
| <b>LOGANIACEÆ</b>                                 |         |                 |      |       |          |
| <i>Strychnos nux-vomica</i> (strychnine).....     | C. G.   | ⊥               | —    | ⊥     | ●        |
| <b>LYTHRACEÆ</b>                                  |         |                 |      |       |          |
| <i>Lagerstroemia speciosa</i> (banaba).....       | b       | +               | +    | +     | ●        |
| <b>MELASTOMACEÆ</b>                               |         |                 |      |       |          |
| <i>Memecylon floribundum</i> .....                | C. G.   | +               | +    | +     | ●        |
| <b>MELIACEÆ</b>                                   |         |                 |      |       |          |
| <i>Sandoricum koetjape</i> (santol).....          | C. G.   | —               | —    | —     | ●        |
| <i>Swietenia mahogani</i> (mahogany).....         | C. G.   | +               | +    | +     | ●        |
| <b>MORACEÆ</b>                                    |         |                 |      |       |          |
| <i>Artocarpus integra</i> (lanka).....            | C. G.   | —               | —    | —     | ●●       |
| <i>Ficus nota</i> (teb-beg).....                  | C. G.   | —               | —    | —     | ●●●      |
| <i>Ficus ulmifolia</i> (isis).....                | H       | —               | —    | —     | ●●●●     |
| <b>MYRTACEÆ</b>                                   |         |                 |      |       |          |
| <i>Eucalyptus globulus</i> (bluegum).....         | b       | +               | +    | +     | ●●●●●●●● |
| <i>Eugenia bordenii</i> (malaruhut).....          | For.    | +               | +    | +     | ●●●●●●●● |
| <i>Eugenia calubcob</i> (kalubcob).....           | b       | +               | +    | +     | ●●●●●●●● |
| <i>Eugenia xanthophylla</i> (tampoi-gubat).....   | b       | +               | +    | +     | ●●●●●●●● |
| <i>Eugenia cumini</i> (duhat).....                | C. G.   | +               | +    | +     | ●●●●●●●● |
| <i>Eugenia jambos</i> (tampoi).....               | C. G.   | +               | +    | +     | ●●●●●●●● |
| <i>Melaleuca leucadendron</i> (cajaput tree)..... | C. G.   | +               | +    | +     | ●●●●●●●● |
| <i>Psidium guajava</i> (guava).....               | C. G.   | +               | +    | +     | ●●●●●●●● |
| <b>OXALIDACEÆ</b>                                 |         |                 |      |       |          |
| <i>Averrhoa bilimbi</i> (kalamias).....           | C. G.   | ⊥               | ⊥    | ⊥     | ●        |
| <i>Averrhoa carambola</i> (balimbing).....        | C. G.   | —               | —    | —     | ●        |
| <b>PALMÆ</b>                                      |         |                 |      |       |          |
| <i>Ptychosperma macarthurii</i> .....             | C. G.   | —               | —    | —     | ●        |
| <b>ROSACEÆ</b>                                    |         |                 |      |       |          |
| <i>Eriobotrya japonica</i> .....                  | C. G.   | ⊥               | ⊥    | ⊥     | ●        |
| <b>RUBIACEÆ</b>                                   |         |                 |      |       |          |
| <i>Ixora odorata</i> .....                        | C. G.   | —               | —    | —     | ●●       |
| <i>Gardenia augusta</i> (rosal).....              | C. G.   | —               | —    | —     | ●●       |
| <b>RUTACEÆ</b>                                    |         |                 |      |       |          |
| <i>Citrus maxima</i> (suha).....                  | C. G.   | —               | —    | —     | —        |
| <i>Citrus nobilis</i> (calamunding).....          | C. G.   | —               | —    | —     | —        |
| <i>Citrus mitis</i> (naranjita).....              | C. G.   | —               | —    | —     | —        |



TABLE OF RESULTS—(Continued)

| FAMILY NAME, SCIENTIFIC, AND COMMON NAMES | HABITAT | BARK OF<br>STEM | LEAF | ROOTS | FRUITS |
|-------------------------------------------|---------|-----------------|------|-------|--------|
| SAPINDACEÆ                                |         |                 |      |       |        |
| Sapindus saponaria.....                   | C. G.   | —               | —    | —     | Q      |
| SAPOTACEÆ                                 |         |                 |      |       |        |
| Chrysophyllum cainito.....                | C. G.   | +               | +    | +     | Q      |
| SOLANACEÆ                                 |         |                 |      |       |        |
| Brunfelsia americana.....                 | C. G.   | 1               | 1    | 1     | Q      |
| VERBENACEÆ                                |         |                 |      |       |        |
| Clerodendron quadriloculare (bagauak).... | C. G.   | —               | —    | —     | Q      |
| Vitex parviflora (molave).....            | b       | +               | +    | +     | Q      |
| VITACEÆ                                   |         |                 |      |       |        |
| Leea philippinensis.....                  | b       | +               | +    | +     | Q      |



## NOTE: EDWARD DEMILLE CAMPBELL

On September 18, 1925, the scientific world lost Prof. Edward DeMille Campbell, whose life was a typical realization of the old time saying: "Where there's a will, there's a way."

Professor Campbell was born in Detroit in 1863. At the age of twenty-six, he was appointed assistant professor of metallurgy in the University of Michigan. After barely two years in this position, he lost his eyesight as the result of an explosion that occurred while he was experimenting on the causes of the hardening of steel. Ten days after the unfortunate accident, he resumed his teaching work.

"His life soon became ordered to the new conditions—a daily hour of physical exercise in the gymnasium, hours when assistants read to him, the preparation of notes written by himself with the Brail typewriter, and many hours of planning. It was this latter element which permitted him to obtain his remarkable success as an investigator, utilizing the hands and eyes of those who were frequently merely undergraduates. No research problem was undertaken unless it could be planned so that the variables could be measured quantitatively and little be left to the uncertain judgment of the experimenter. He developed his memory marvelously. He would take the results of experimental work day by day, make approximate mental calculations, and visualize the trend of a series of tests in a way which was extraordinary. He once said that he aimed to know more about each student's work than the student did himself, and he did."<sup>1</sup>

In spite of his serious handicap, Professor Campbell remained in the University of Michigan until his death. He published no less than seventy-seven research papers. In 1902 he organized the course in chemical engineering and since 1905 was director of the chemical laboratory. He also served in the Senate of the University.

"No one possessed of his normal faculties can fail to find encouragement in the thought that here was a man, blind since 1892, who nevertheless continued steadfastly in a profession where progress would seem to be impossible without eyesight, and achieved the distinction of becoming chairman of a great department in a great university. . . .

"If one so handicapped could be cheerful, productive in his work, and constructive in his thinking, how can the average man complain of his lot and be satisfied with less than his best?"<sup>2</sup>

—F. O. SANTOS

<sup>1</sup> Editorial: *Journal Industrial Engineering Chemistry* 17: 1103. 1925.

<sup>2</sup> White, A. H. *Journal Industrial Engineering Chemistry* 17: 1204. 1925.

## EXCHANGE NOTES

When John Wolfskill in 1877 shipped the first carload of oranges from California to St. Louis he little dreamed that within fifty years it would be multiplied to an annual total of more than 50,000 cars of citrus fruits. And what has been done with the citrus fruits will undoubtedly be done in the future with walnut, fig, avocado and date, not to mention many others which will undoubtedly rapidly increase in importance. It appears likely that much of the acreage in California now planted to fruits of the temperate zones will gradually be replaced by subtropical fruits and nuts.

—*The Journal of the Madras Agricultural Students' Union.*

He who lives on a farmstead on which flowers have a part lives more fully. . . .

Men should take a greater interest in making the home and its surroundings more attractive. The pleasures derived from flowers yield a high rate of interest and are an investment in contentment which goes far to pay off the mortgage.

—*The Agricultural Student* (College of Agriculture, Ohio, U.S.A.)

A possible new use for cacao, which may in the future considerably increase its consumption, has been found in the development of cacao bread. The United States Department of Agriculture carried out experiments which resulted in a bread being prepared in which from 8 to 10 per cent. of the flour used was substituted by cacao powder, and the shortening usually supplied was omitted, as this is supplied by the cacao, presumably by the fat which it contains. This bread has now been manufactured in Trinidad according to the United States' recipe and has been pronounced by many who have tried it to be very palatable and likely to meet with some demand. If such a demand became general the consumption of cacao might be increased.

—*Tropical Agriculture.*

Paint and varnish are among our most useful inventions. They preserve wood and metal surfaces from decay and rust, and add to their beauty.

—*The Prairie Farmer.*

It is predicted that tractors will come into use in Negros, Philippines, as soon as the high cost of combustion engine fuel is reduced by the manufacture of alcohol from molasses.

—*The Australian Sugar Journal.*

The 500-pound Fat Club is a farmers' club. A good cow fed farm feeds and properly cared for can become eligible to membership. One Holstein cow owned by Walter Taylor of Peoria County produced 6,675 pounds of milk and 216.2 pounds of fat in 90 days. She is an ace-high member. Her record for three months is 2,600 pounds of milk and 66 pounds of fat more than the average cow in Illinois produces in a year. We ought to have more like her in this country.

—*The Prairie Farmer.*

Observations taken in Yorubaland, West Africa, show that earthworms are capable of bringing to the surface annually, in the form of "casts" 62,200 tons of soil per square mile. In less than thirty years every inch of soil to a depth of two feet is treated in this way, thus ensuring natural ventilation and drainage.

In an acre of average soil there are roughly 200,000 worms, each of which acts as a miniature mill grinding the soil far more finely than any man-made contrivance could do. When the farmer ploughs his land, he merely does on a larger scale what worms have been doing for centuries.—THE HINDU.

—*The Journal of the Madras Agricultural Students' Union.*

Nature is a great producer, but not a discriminating one. She abhors a barren field, but a crop of quack grass is as satisfactory to her as a crop of wheat. She makes no distinction between grasshoppers and honey bees, or between the cow and the germs that are trying to destroy it. All of which is only another way of saying that man is unimportant in the eyes of Nature. Nature peoples the earth with life, but whether that is human life and the plants and animals necessary to its existence, or thistles and tree toads makes not one whit of difference to her.

—*The Prairie Farmer.*

## COLLEGE AND ALUMNI NOTES

The sixteenth scientific meeting of the Los Baños Biological Club was held in the evening of November 24, 1925. A paper on "The viability of farm crop seeds as affected by different methods of storage" by Dr. Toribio Vibar and Mr. Pedro A. Rodrigo was read by Doctor Vibar. A paper on "The status of nutrition among students in the College of Agriculture" by Dr. F. O. Santos and Mr. E. G. Collado was read by Doctor Santos. Doctor Eduardo Quisumbing read a paper on "Anatomical studies of Para rubber, *Hevea brasiliensis* (HBK.) Muell. Agr.

The College Dramatic Club presented "The Hidden Symbol" by Carlos P. Romulo on the evening of December 12. The cast of characters (in order of appearance) were:

|                            |                      |
|----------------------------|----------------------|
| Don Emilio Agudo.....      | Gaudencio A. Ventura |
| Josefina Agudo.....        | Gregoria Villa       |
| Don Felipe Interior.....   | Narciso Rosero       |
| Máximo.....                | Brígido Huligaña     |
| Luis Interior.....         | Felix Villa          |
| Lieutenant Cardona.....    | Nicolas Florese      |
| Presentación Interior..... | Juliana Fronda       |

The play was directed by Miss Margaret Wilson of the Department of English.

Between the two acts was a cornet solo "Carnival of Venice" by Gabriel Gonzales with Eugenio Eubanas at the piano; and a quintette "Oh, Don't I, Though" by the College Bow-wows. The overture was played by the College Orchestra.

Mr. José Sanvictores, former Director of Bureau of Non-Christian Tribes, and now in charge of the Roces live stock interests in Bukidnon, purchased a grade Hereford-Native bull from the College for use in the improvement in conformation of the Indian cattle on the Roces Ranch.

The Calamba Sugar Estate purchased from the College two pure Indian Buffalo bulls to be used in grading up the Estate's carabao herd. These bulls mate readily with the native carabao, which is not always the case with their kind. Indian buffaloes stand the heat of the sun and endure work in the field about as well as common oxen.

The Department of Animal Husbandry has just acquired an excellent specimen of an imported Anglo-Nubian buck from the Calamba Sugar Estate. This breed is one of the largest and best reputed of milk goats.

Mr. Severo J. Mariano, B. Agr. '20, College of Agriculture; M. S. '23, Louisiana State University, recently returned to the Philippines. While in America Mr. Mariano worked as assistant and chief chemist at Glenwild Sugar Factory, Berwick, Louisiana, and also at Central Jagueyal of the Cuba Cane Sugar Corporation, Camaguey, Cuba. He was employed one summer with the American Agricultural Chemical Co. of Baltimore.

*New books and other publications added to the library of the College of Agriculture, November, 1925*

Bulfinch, Th.

The age of fables or beauties of mythology, revised.

Campbell & Detwiller

The lazy colon. 1925.

Cervantes, M. de

Don Quixote of La Mancha.

Fraser, M.

Prices in New Zealand. 1920

Heineman, P. G.

Milk. 1921 Illustrated edition.

Keller, A. G.

Starting point in social science. 1925.

Smiles, C.

Character. 1924.

The New Zealand official yearbook, 1925.